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SCIENCE OF HOME AND COMMUNITY

A TEXTBOOK IN GENERAL SCIENCE

REVISED EDITION

BY

GILBERT H. TRAFTON

INSTRUCTOR IN SCIENCE
STATE TEACHERS COLLEGE, MANKATO, MINNESOTA

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PREFACE

Education for the present life of the child should be the chief purpose of our schools. This book seeks to carry out this principle so far as science is concerned. We are living in the midst of a great scientific age. Applications of science more and more dominate our life, and they will continue to do so in ever increasing degree. Any sane system of education must see to it that boys and girls living in the midst of these applications of science, which form such an important part of their everyday life, are educated in terms of this environment in order that they may better appreciate it and adapt themselves to it. This book is an attempt to make clear to boys and girls answers to some of the questions that naturally arise in their minds concerning the common applications of science.

The book is not written as an introduction to, or preparation for, any later science work. It is written to meet the *present needs and interests* of boys and girls just entering the adolescent period. We do not know the future of the child, but we do know his present. The satisfaction of these present needs is the best possible and the only sound foundation for any further work in science that he may do in later years.

If a course in General Science is to be worthy of an established place in the school curriculum, it must fulfill two requirements: First and foremost, it must appeal to the pupils; and second, it must be well organized around centers of children's interests.

The author has tried to meet these two requirements by finding the basis for both the selection and the organization of material in the applications of science to the child's immediate life. It seems best to group these applications around two great centers — the home life and the community life. There are certain phases of science that are more conspicuous in the home circle, while there are other phases that are more prominent as one goes out into community life. While these phases are closely interrelated, and while in some cases no sharp line can be drawn between them, the author believes that from the child's standpoint this division forms a natural basis for organizing the text.

The material has been organized from the human rather than from the scientific point of view. The child sees first the uses made of various things; then he is interested to understand something of the construction and the mode of operation of the machines involved; and finally he wishes to know what their history has been. Consequently the great inventions have been treated from the four standpoints of their uses, their history, their construction, and their working.

This is not a textbook in General Science in the sense that it attempts to cover a little of *all* the sciences, just for the sake of covering them all. The extent to which any particular science is included depends on the part that the science plays in the immediate life of the child. Whether any particular science or any particular topic in a science should form a part of the course depends on the number and value of the elements that it possesses in common with the child's life. As a matter of fact, the two sciences that are especially conspicuous in the child's daily life and that consequently dominate the text are physics and hygiene.

A recent study of nine high-school texts in General Science, Biology, and Chemistry made by S. R. Powers, of Columbia University, showed two significant facts: First, each of these books contained from 1,257 to 2,270 words not found in Thorndike's *Teacher's Word Book* of the ten thousand most widely used words; and second, more than half (52 per cent) of these words occurred but once.

With the results of this investigation in mind, the author has paid special attention to the simplification of the vocabulary in this revision. The original manuscript was checked up with the *Teacher's Word Book*, and a list of the words not found there was made, with the frequency of occurrence of each of these words indicated. Nearly all of the words that occurred but once were eliminated in the revised text. The other words were carefully scrutinized, and, as far as possible, more widely used synonyms were substituted for the words of general meaning. In the case of the new words that the topic under discussion necessarily required, the general plan was followed of either giving a direct explanation of the meaning or suggesting the meaning by the context.

For many helpful suggestions the author takes pleasure in acknowledging his indebtedness. Mr. Austin C. Lescarboura, of the *Scientific American* staff, has read and criticized the entire manuscript. The following have read and criticized portions of the manuscript: Professor Benjamin G. Elliott, of the University of Wisconsin; Mr. C. H. Claudy; Professor George J. Miller, of the Mankato State Teachers College; Mr. P. M. Ferguson, Manager of the Mankato Citizens Telephone Co.; Dr. Orianna McDaniel, of the Minnesota State Board of Health; and Professors William C. Beal, R. V. Beard, J. W. Buchta, Basil I. Burrill, C. E. Cary, E. G. Cheney, H. S. Diehl, John V. Martenis, George C. Priester, Charles F. Shoop, and Anthony Zeleny, of the University of Minnesota.

The author wishes to make special acknowledgment of the kindness of Mr. H. A. Whittaker, Director, Division of Sanitation, Minnesota Department of Health, who gave many valuable suggestions

on the chapters dealing with milk and water and also granted permission to quote freely from certain publications on these topics issued by the State Board of Health.

Acknowledgments are made to my son, Leroy H. Trafton, for assistance in checking up the manuscript with Thorndike's *Teacher's Word Book*.

The author acknowledges his indebtedness to the following firms for their courtesy in allowing illustrations from their publications to be used in this book: American Book Company; The Century Company; Doubleday, Page, and Company; E. P. Dutton and Company; *Everybody's Magazine;* Ford Motor Company; Ginn and Company; Harper and Brothers; Norman W. Henley Publishing Company; George W. Jacobs and Company; J. B. Lippincott Company; A. C. McClurg and Company; Frederick A. Stokes Company; Whitcomb and Barrows; The Portland Cement Association; and The Consrad Company. The illustration of the first telephone is taken, with Mr. Casson's permission, from his book, *History of the Telephone.*

NOTE TO TEACHERS

The practical work outlined in this book has been divided into four kinds: laboratory exercises, demonstrations, field exercises, and projects.

It is intended that the laboratory exercises shall be performed by each pupil individually. The demonstrations are to be performed before the entire class, either by the instructor or by some pupil. The results of recent studies reported by Dr. E. R. Downing seem to indicate that the demonstration work may be fully as valuable as the individual laboratory work, and possibly in some cases even superior to it. Another point to consider in this connection, especially in the small high school, is the expense. The cost of the equipment needed for demonstrations is much less than the cost of that needed for individual work, which requires duplication of materials. Taking into account, therefore, both these considerations — utility and cost — it would seem wise to recommend that the schoolroom exercises should consist chiefly of demonstrations. The pupils may take turns in performing these demonstrations before the class. However, the pupil should first perform the experiment alone with the teacher's aid before conducting the class demonstration.

The field exercises are to be performed by the instructor and class outside of the schoolroom.

In the projects something is provided for each pupil to do individually outside of the laboratory. These projects have been divided into three groups: for the home, for the school, and for the community. They provide a vital kind of work because they connect the school with actual life and provide opportunity for the pupil to do something on his own responsibility. It is suggested that a certain number of home projects be required of each pupil, who may be allowed to choose the ones he wishes to carry on. The pupils should be expected to present definite written reports of the projects and should be given school credit for the work done. A sufficient variety of projects has been given so that each pupil can find some suited to his circumstances.

The author believes that the pupils should make written records of all the practical exercises. These records, kept in a notebook, should be brief and simple in form. It is suggested that each record contain, first, a statement of the purpose of the exercise; second, a brief description of what was done; and third, a statement of the things learned or the conclusions drawn from the exercise.

Questions at the beginning of each chapter are given as problems to guide the pupils in their study. These, together with the questions at the end of the chapter, are suggested as a basis for the class discussions. It is believed that a few leading questions of this type will stimulate the pupils to independent thought and to organization of their knowledge.

In order to adapt the work to the individual interests and capabilities of the pupils, it seems desirable that they make reports to the class on some subjects of which they have made special study. As an aid in this kind of work a few references are given at the close of each chapter. In order to help students to fix the important points of the text in mind, a brief outline summary is given at the end of each chapter.

The stress to be laid on the various chapters depends on whether the environment of the pupils is urban or rural. In accordance with this environment, some chapters may be passed over lightly, while others should receive special attention.

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PART ONE

SCIENCE OF THE HOME

Section A. BUILDING THE HOME
Section B. HYGIENE OF THE HOME
Section C. ELECTRICITY IN THE HOME
Section D. RECREATION IN THE HOME
Section E. USE OF THE HOME GROUNDS

SCIENCE OF HOME AND COMMUNITY

CHAPTER I

BUILDING MATERIALS

What is the best building material?

Wood

Importance. Of all the building materials wood stands first in importance, as it is the most widely used. Not only is it commonly employed in constructing the exteriors of houses, but even in brick and concrete buildings it is used for the framework and for inside finish. Many substitutes are taking the place of wood, and in many cases the substitution of fireproof substances is highly advantageous; however, there are many uses of wood for which at the present time no substitute seems possible or desirable.

Classes of woods. Woods are commonly divided into two classes: softwoods and hardwoods. These terms mean that on the *average* the trees in the second group are harder than those in the first group. Some trees in the hardwood group are softer than some in the softwood group; and some in the softwood group are harder than some in the hardwood group. The softwoods are sometimes called evergreens or needle-leaved trees, and the hardwoods are sometimes called deciduous or broad-leaved trees.

Structure of wood. Wood is composed of tiny cells, which can be seen as separate units when viewed under the microscope. At one time in the life of the tree these cells were living. Now the living portion is gone and only the cell walls are left. These cells give wood a porous character and explain many of its qualities, such as its lightness and its nonconducting properties. On account of these pores preservatives can be forced into the wood, and paint and varnishes can be easily applied.

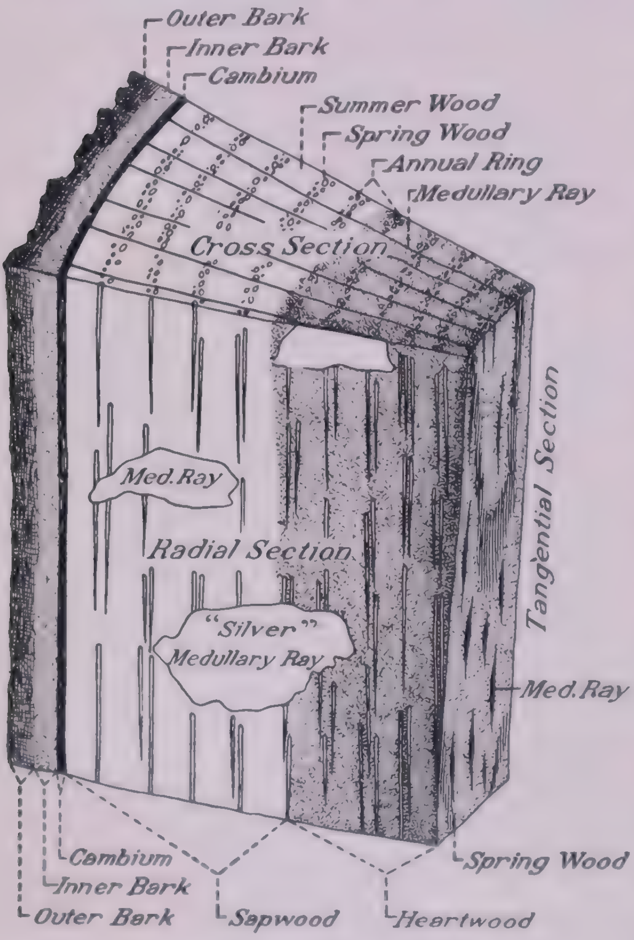

Fig. 1. — Structure of wood

The central part of a tree is called the heartwood, and the outer part next to the bark is called the sapwood. In some trees there is a marked contrast in color between these, the heartwood being much darker.

If one looks at the freshly cut surface of a stump, a series of rings is usually visible. Since each ring represents a year's growth, one may learn the age of the tree by counting the rings. These distinct rings are due to the fact that, for trees grown in a temperate climate, the texture of the summer growth is different from that of the spring growth. Hence we can distinguish between summer wood and spring wood.

Woods are sometimes classified as porous and non-porous. The softwoods are non-porous and the hardwoods are porous. The latter are of two types, the ring-porous and the diffuse-porous. In ring-porous woods, larger pores appear in the spring growth than in the summer growth; while in the diffuse-porous woods, pores of about equal size are scattered through the entire width of the ring.

Other structures found in wood are the pith rays, which extend as light lines from the center to the circumference, much like spokes of a wheel.

By careful study of these structures in various kinds of wood, an expert can learn to name the different species. While identification is a difficult task if applied to all trees, yet it is not hard to identify a few of the more common woods used in the home.

The appearance of spring wood, summer wood, and pith rays depends on the way in which a board is cut. In quarter-sawed boards the cut is made nearly parallel to the pith rays. This cut exposes broad, shiny portions of the pith rays, known as mirrors, which give the wood a very attractive appearance. In a tangent cut, the tree is sawed at nearly right angles to the pith rays. A cut made at right angles to the length of the tree is called a transverse section.

LABORATORY EXERCISE 1

Purpose. To learn how to tell the cuts of wood found in chairs and desks.

Materials. Collection of samples of wood showing different cuts. These may be obtained from a carpenter's shop. Transverse sections of a large branch or small tree.

Directions. 1. Examine specimens of wood till you find each of the following:

a. Sapwood and heartwood. How do they differ?

b. Annual rings of growth. What differences do you find among the different rings in the same piece of wood? How old is the branch?

c. Spring wood and summer wood in each ring. How do these differ?

d. The pores. Find (1) a ring-porous wood; (2) a diffuse-porous wood; (3) a non-porous wood.

2. Make drawings of: (*a*) a transverse section; (*b*) a quarter-sawed section; (*c*) a tangent section.

3. In each of the three drawings show and label: (*a*) annual rings of growth; (*b*) summer wood; (*c*) spring wood; (*d*) pith rays.

4. Make a drawing about three inches square of a piece of the desk and label the parts that show. In which of the three ways was it cut?

Useful properties of wood. Among the properties of wood that make it useful are the following: weight, hardness, durability, strength, and toughness. These properties differ somewhat according to the kind of wood.

The following tables show some of the extreme differences for a few woods.

QUALITIES OF WOODS

WEIGHT		
Very light	*Medium*	*Very heavy*
Redwood	Black walnut	Mockernut hickory
Balsam fir	Eastern larch	White oak
White pine	Black cherry	Hard maple
HARDNESS		
Very hard	*Medium*	*Very soft*
Hickory	Cottonwood	Basswood
Hard maple	White elm	Willow
Rock elm	Tamarack	Spruce
DURABILITY		
Very durable	*Medium*	*Very perishable*
Red cedar	White pine	Basswood
Black walnut	Red oak	Willow
Redwood	Butternut	Paper birch
TOUGHNESS		
Very tough	*Medium*	*Easily broken*
Hickory	Willow	Western red spruce
Rock elm	Birch	Cypress
Honey locust	Black cherry	Basswood

Seasoning. Lumber when first cut contains a large amount of water, which often constitutes half the entire weight of the wood. Before the wood is used, a large percentage of this water is removed by a process called seasoning. This drying improves the wood in the following ways: (1) It reduces the shrinkage and warping after the wood is made into the finished product; (2) it usually increases the strength, hardness, and stiffness of the lumber; (3) it increases the durability by decreasing danger from decay; and (4) it reduces the weight.

Two methods of drying are used: the natural method (air-drying) and the artificial method (kiln-drying). These methods differ in the following ways: (1) The kiln method is much quicker. Air-drying requires from several months to a year, while the kiln method requires only a few weeks or days. (2) The kiln method removes a larger percentage of moisture. Air-dried timber contains from 15 to 30 per cent of moisture, while kiln-dried contains only from 5 to 10 per cent. For the ordinary construction work of a building, the air-dried lumber can be used; but for the finer uses of wood indoors in finishing, flooring, and furniture, kiln-drying is necessary to reduce further the percentage of moisture. (3) The kiln-dried lumber absorbs less moisture from the air than does the air-dried.

In many cases both methods are used, the wood being first air-dried and later kiln-dried.

Advantages of wood. We will finish our discussion of wood by summarizing briefly its advantages: (1) It is widely distributed and easily obtainable; (2) it is easily worked with common tools and can be formed to fit joints; (3) it is very strong for its weight; (4) it offers an unusual combination of strength, toughness, and elasticity; (5) it does not conduct heat; (6) it does not contract and expand with changes in temperature; (7) it has a very beautiful appearance, which makes it available for decorative purposes.

The one great objection to the use of wood for the exterior of buildings is the fact that it burns so readily. (Chapter V discusses the problem of fire prevention in the home.) The use of brick and concrete as substitutes for wood in building is very desirable, since thereby the loss from fires would be reduced. It is especially desirable that some substitute for wooden shingles be used, since sparks on roofs are the second most common cause of the fires in dwelling houses, 9 per cent of all fires being started in this way, with an annual loss of over $5,000,000. Many satisfactory fireproof materials may be used for roofing, such as slate, asbestos shingles, composition shingles, and tile. However, although these substitutes may be used for the exterior of the buildings, wood still remains necessary and desirable for indoor finish.

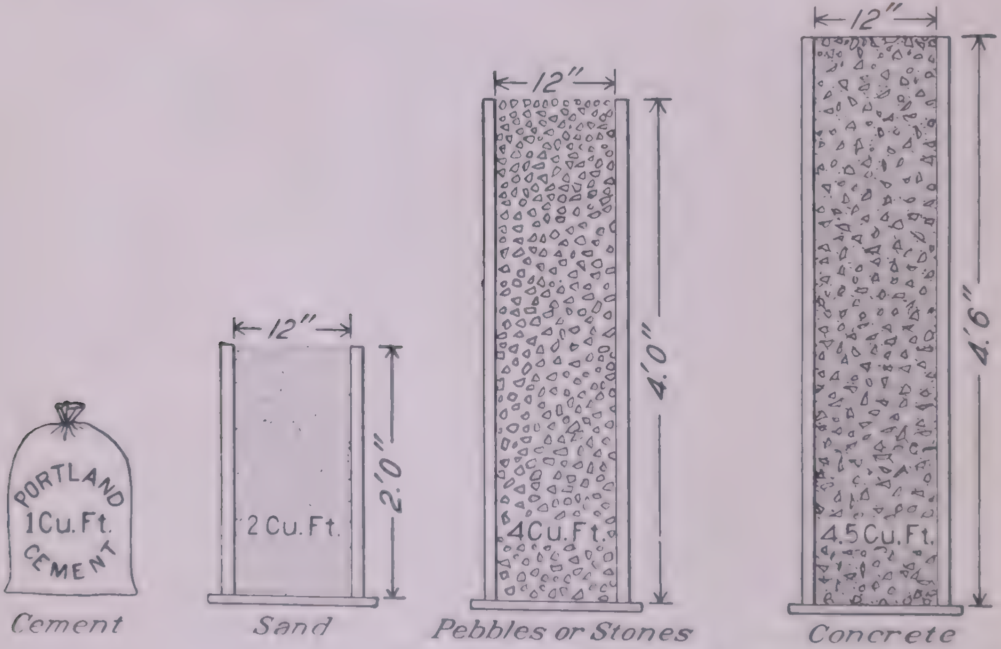

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Fig. 2. — Cement, sand, and pebbles in the proper proportions, when mixed with water, to harden into the solid mass that is concrete

Note that 1 cu. ft. of cement, 2 cu. ft. of sand, and 4 cu. ft. of pebbles do not make 7 cu. ft. of concrete, but 4.5 cu. ft.

CONCRETE

Advantages. In recent years the use of concrete for building has increased greatly, and it seems destined to play an even more important part in the future. Concrete possesses many properties that make it a very satisfactory building material. Among them are the following: resistance to fire, permanence, strength, wearing qualities, and watertightness. The wide distribution of the materials entering into the composition of concrete, the ease with which it may be prepared, and the low cost of upkeep of the finished building are other factors which help to explain the wide use of concrete.

Composition. Concrete is made of the following four substances: cement, sand, gravel or crushed stone, and water. The proportion of these substances varies according to the use to which the concrete is to be put. This proportion is expressed in figures. For example, a 1–2–4 mix-

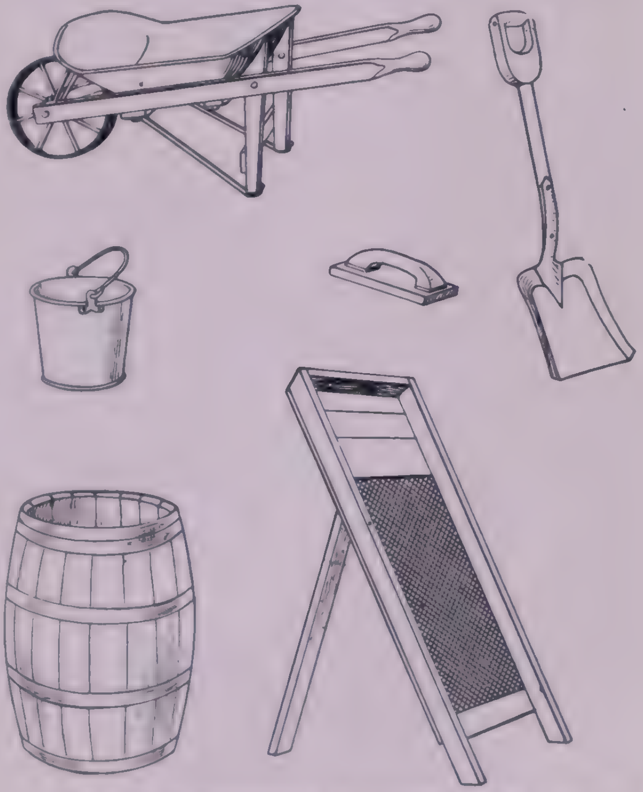

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Fig. 3. — Simple tools for making and placing concrete

Water barrel and bucket; steel pan wheelbarrow for handling dry aggregate and concrete; sand-screen for proper grading of aggregates; square-pointed shovel for turning and mixing concrete; and wooden float for finishing.

ture is one part of cement (by volume), two parts of sand, and four parts of gravel. The first figure stands for the cement, the second for the sand, and the third for the gravel or crushed stone. However, the resulting volume is not equal to the sum of the three, but equals only a little more than the volume of the gravel. For instance, the above mixture would make, not seven parts of concrete, but only 4.5 parts. The particles of sand fill the spaces between the pieces of gravel, and these particles are held together by the cement.

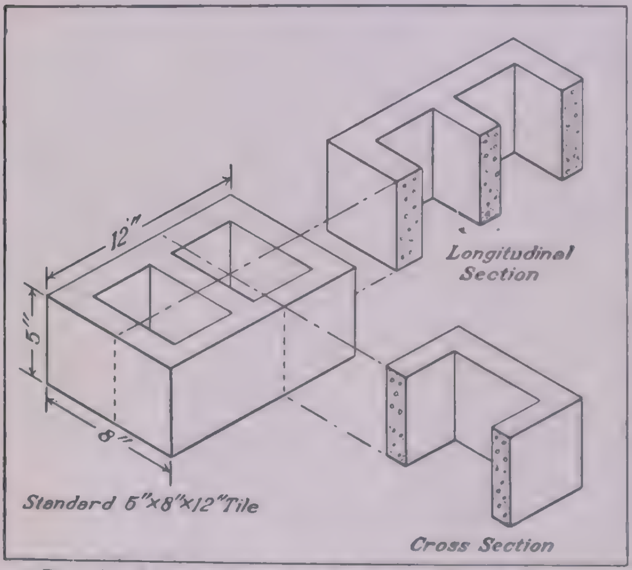

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Fig. 4. — Standard type of concrete block

A richer mixture would contain a larger proportion of cement, and a leaner mixture a smaller proportion. In order to get a water-tight product a rich mixture is used, a 1–2–3 combination. Since cement is the most expensive part of the mixture, sometimes contractors have been tempted to use a smaller proportion of cement than their contracts called for, with the result that the buildings were weakened.

A chemical change takes place between the cement and the water, as a result of which a new compound is formed. The process of hardening is not one in which the water dries out, but one in which the water unites with the cement. Hence a certain amount of water is absolutely necessary. While the mixture hardens to some extent within a few hours, the chemical change continues to go on longer, sometimes for a year, during which time the concrete is becoming stronger.

Cement is made by heating a mixture of clay and limestone to such a high temperature that the materials begin to fuse in the form of clinkers. These are then ground to a fine powder, with which is generally mixed a small quantity of gypsum.

Use of concrete in building houses. Concrete may be used in the following ways: (1) in houses built of blocks, (2) in unit-built houses, (3) in monolithic houses, and (4) in plastered concrete houses.

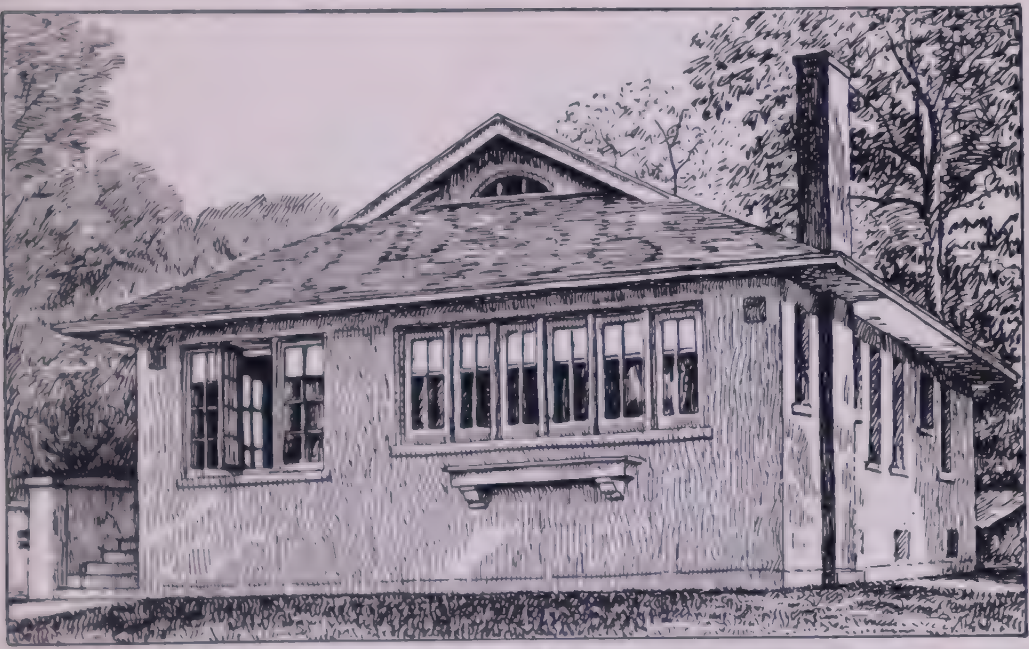

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Fig. 5. — Concrete house

The concrete or Portland cement stucco finished house has beauty and charm. Upkeep expenses are reduced to the minimum.

A concrete block usually contains a dead-air space. The blocks may be built into walls like bricks.

A house in which the beams, wall slabs, floor slabs, and partitions are cast at one place and then carried to the building site, where they are assembled to form the building, is called a unit-built house. This type of construction is specially adapted to conditions under which it is desired to make a large number of similar houses.

Monolithic houses are made by pouring the concrete into molds, in which it hardens to form a solid structure.

In the plastered concrete house a framework is first erected and covered with wire mesh or metal laths. This is then covered to a depth of about two inches with concrete. In some cases use is made of products in which wooden laths are supplied already mounted on heavy tar paper, which need merely be nailed over the sheathing and then plastered with the stucco coating. Such a support is cheaper than wire mesh or metal lath, but is hardly as satisfactory. However, this form of construction is being extensively used because of its cheapness.

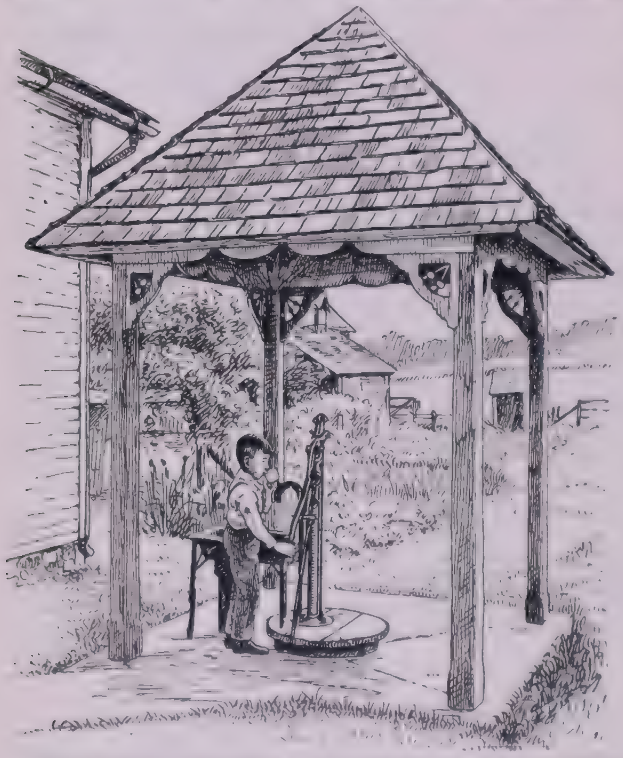

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Fig. 6. — Concrete well curb

The modern version of the old oaken bucket. A tile-lined well with a clean concrete platform means pure water.

Other uses. Besides its use in constructing the main part of a building, concrete is very widely used for cellar floors and for foundations of all sorts of buildings.

In addition, concrete is well suited to the construction of many things around the home, such as the following: cisterns, fence posts, garages, steps, sidewalks, porches, well curbs, flower boxes, and driveways.

In the construction of such articles as fence posts, wooden forms are made, into which the concrete is poured and in which it is allowed to harden. In order to give greater strength to the posts, the concrete may be reinforced by means of iron rods imbedded in the concrete while it is soft.

BRICKS

Advantages. The two chief advantages of brick as a building material are its permanency and its resistance to fire. Furthermore, the cost of upkeep is very small. The porous character of bricks makes them poor conductors of heat; hence they tend to keep cool in summer and warm in winter. While the first cost of brick is more than that of wood, in the long run brick is really cheaper.

Methods of making bricks. Three methods are used in making bricks from clay or finely powdered shale: the soft-clay process, the stiff-clay process, and the dry-press process. In the soft-clay process the clay is pressed into molds either by hand or by machinery. In the stiff-clay process the clay is mixed with just enough water to form a stiff mud and is then forced through rectangular openings in a machine much like a sausage-grinder. The long bar is then cut into bricks of the desired length by means of wires stretched across a frame. In the dry-press process the materials are ground to a moist powder and then shaped under great pressure into the desired forms.

In each of the processes the bricks are allowed to dry for a few days and are then subjected to fire in kilns at a high temperature, varying from 1,500° to 2,200° F. The color of the finished bricks depends on two factors: the kind of clay used and the temperature of the kiln.

Types of brick houses. The solid brick house is the kind that has been made most commonly. In this type the bricks are laid on their broad surface in two rows close together, a solid eight-inch wall thus being made. Recently another type of brick house known as the Ideal Wall is being constructed, in which there is an air space between the rows of bricks. There are two ways of laying this wall. In one type, all the bricks are laid on the narrow edge with the broad surface exposed; in the other type, the inner row of bricks is laid on edge while the outer row is laid in the usual way on the broad surface. The Ideal type is cheaper than the solid type, because less material is needed and because it has been found possible to apply plaster directly to the brick surface, thus saving the cost of the laths and other lumber generally used. It is claimed that this type of house can be built as cheaply as the wooden house.

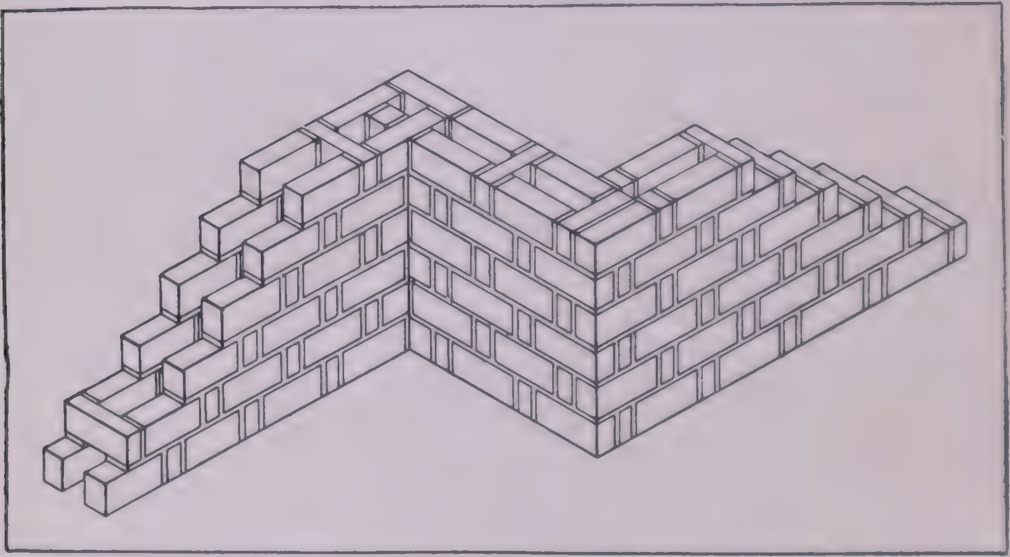

Fig. 7. — Ideal wall; a cheaper way of laying bricks

Brick bond. Bond is a word applied to the overlapping of the bricks in the different rows in such a way as to stiffen the wall. In describing the different kinds of bond, two terms are used — "stretcher" and "header." A stretcher is a brick laid lengthwise of the wall, showing its long face on the surface; a header is a brick laid at right angles to the direction of the wall, showing its end on the surface. The use of headers strengthens the wall along the line of its thickness.

There are three fundamental types of bonds: the Running, the English, and the Flemish. In the Running bond, the bricks are all laid as stretchers, with the result that the wall is weak throughout its thickness. In a form of this type known as the American bond, every sixth row is laid as headers. In the English bond, alternate rows of stretchers and headers are laid. In the Flemish bond, stretchers and headers alternate in each row. Many variations of these three types are found.

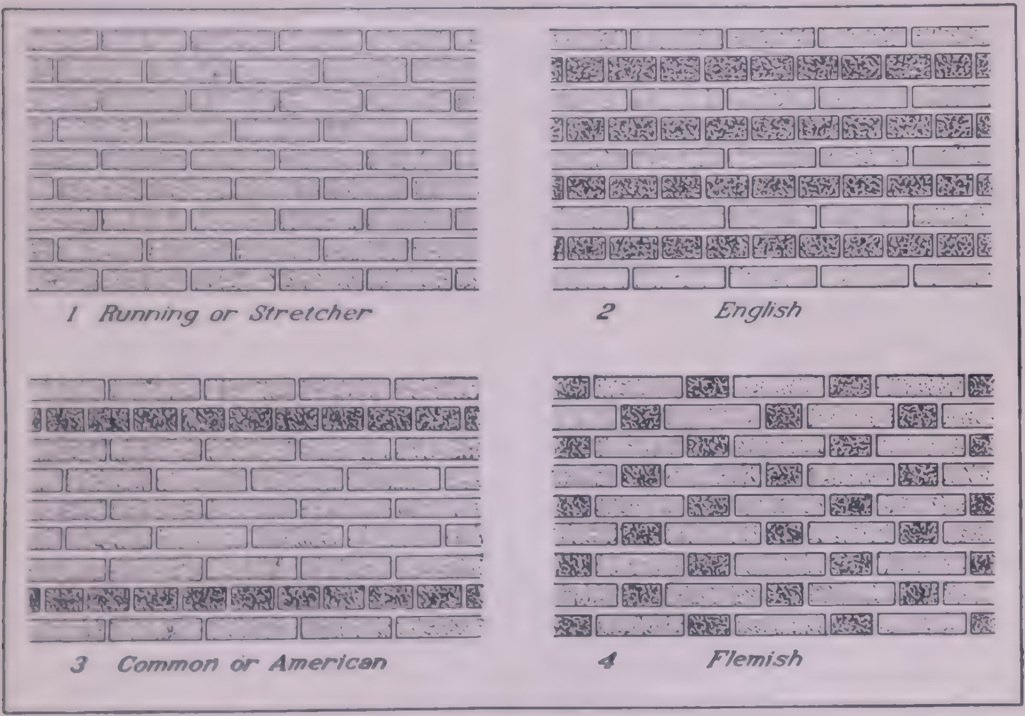

Fig. 8. — Various kinds of bond in brickwork

While the chief purpose of these various combinations is to furnish strength to the wall, they may also be made ornamental through the patterns that may be worked out by different bonds and different colors.

DEMONSTRATION 1

Purpose. To test the water-absorbing quality of a brick.

Apparatus. Half a brick; scales for weighing.

Directions. 1. Dry the half brick in an oven.

2. Weigh it.

3. Boil it in water for five hours.

4. Allow it to remain in the water until the latter has cooled to the temperature of the air.

5. Take out the half brick and weigh it.

6. Find the weight of water absorbed, by subtracting the weight when dry from the weight when taken from the water.

7. Find what percentage the weight of the water is of the weight of the dry brick. This is the percentage of water absorption.

8. For good facing bricks molded from soft clay, the absorption should not exceed 15 per cent; and for stiff-molded or dry-pressed bricks, it should not greatly exceed 10 per cent.

BUILDING-STONES

Kinds of stones used. The use of stones for ordinary building is limited, being confined to sections near the quarries where the stones are obtained, since the cost of transportation to great distances is large. The most commonly used stones for building are sandstone, limestone, and slate (for roofs). Marble and granite are used chiefly for monuments and for ornamental purposes on large buildings. These stones are so valuable that they are transported long distances.

Weathering of stones. The use of building-stones depends on appearance, durability, and cost. The durability of stones depends on their resistance to the action of weathering agents, such as frost, changes of temperature, oxygen, carbon dioxide, and water. (See page 539.) The effect of these weathering agencies varies according to the different stones. The chemical action of rain water is most marked on marbles and limestones. Sandstones, if very porous, are affected by frost. Granites are the most durable of all stones, being affected but slightly by these various agencies.

LABORATORY EXERCISE 2

Purpose. To learn some of the differences between building-stones.

Materials. Samples of sandstone, limestone, marble, and granite. Hydrochloric acid.

Directions. 1. Put a few drops of hydrochloric acid on each stone. What difference in the action of the acid do you notice?

2. Scratch each with the point of a knife. How do they differ in hardness?

3. Weigh each stone. Allow each to soak in water for a few hours. Weigh each again. How much water has each absorbed? What percentage is this of the weight of the dry stone? Which stone is most porous?

4. What does the information gained from this study show about the weathering of these stones?

PAINTS

Uses and composition. Paints are used for two purposes: for protection and for ornament. The two most important ingredients of paint are the solid, called the pigment, and the liquid, called the vehicle. Two other ingredients are the thinner and the drier. When the paint is exposed to air, it dries and hardens. In this process, the vehicle undergoes a chemical change by absorbing oxygen from the air. A hard coating is thus formed which protects the substance beneath from further action of the air.

Pigments. A paint pigment should possess the following qualities: (1) It should have sufficient hiding-power to cover the surface beneath; (2) it should form an opaque coating; (3) it should consist of finely divided particles; and (4) it should have no injurious action on the surface to which the paint is applied.

The substances most commonly used for pigments are red lead, white lead, and zinc oxide. The last two when used alone produce a white color. To produce other colors, various substances are mixed with them. For inside painting, lithopone is used very largely as a pigment.

Other ingredients. The most common vehicle used is linseed oil. The best thinner is turpentine, which is added to make the paint spread more easily. Driers are added to paint to make it dry more rapidly. For this purpose several substances are used, such as salts of lead or manganese dissolved in oil or turpentine.

DEMONSTRATION 2

Purposes. To illustrate the action of drying-oils in paint, and to prepare pigments.

Apparatus. Four plates of glass; gasoline; mineral oil; linseed oil; chemicals called for in directions 4 and 5.

Directions. 1. Coat one of these plates with a thin film of water, a second with gasoline, a third with a heavy mineral oil, and a fourth with linseed oil.

2. Expose all four to the air for several days.

3. At the end of this time examine each piece of glass. What difference do you notice between them? Note especially the character of the linseed oil.

4. To make a yellow pigment, add a solution of lead nitrate to a solution of potassium chromate. Filter; then wash and dry the precipitate.

5. To prepare a scarlet pigment, add a solution of potassium iodide to a solution of mercuric chloride. Filter; then wash and dry the precipitate.

Preparing the surface. In order to prepare the surface for the application of paint, it should be cleaned and dried. If it is a repainting job, the old paint should be removed with sandpaper or with a stiff wire brush. Holes and cracks should be filled with putty.

Applying the paint. The first coating applied is a priming, which differs from paint in that it contains a larger proportion of liquid. The purpose of the priming coat is to fill up the pores in the wood and to form a firm basis for the paint proper.

After the priming coat has dried, the paint is applied. It is usually put on in two or three coats, enough time being allowed between the applications for the paint to dry.

Theory of color. For decorative effects, paints are used to produce a great variety of colors. The colors red, yellow, and blue, which cannot be produced by mixing any other colors, are called primary. The remaining colors, which may be obtained by mixing two of these in various proportions, are called secondary.

If we look at a rainbow, we see the colors always arranged in the following order: red, orange, yellow, green, blue, indigo, violet. Sunlight is composed of all these colors taken together. When light passes through drops of water, it is broken up into these separate colors, which we see as the rainbow. While white means the combination of all these colors in the sunlight, black means the absence of all of them.

LABORATORY EXERCISE 3

Purpose. To illustrate the principles of color-mixing.

Apparatus. Bradley color top.

Directions. 1. Set up the top according to the directions accompanying it.

2. Try many combinations of colors and note the resulting colors. Put your records in your notebook in a form like the following:

TWO COLORS USED	PROPORTION OF EACH	RESULTING COLOR

3. Try all the colors of the rainbow and see if you can get white.

4. Try mixing colored crayons and see if you get the same results as with the top.

OUTLINE SUMMARY

BUILDING MATERIALS

- I. Wood
  - 1. Importance
  - 2. Classes of woods
  - 3. Structure of wood
  - 4. Useful properties of wood
  - 5. Seasoning
  - 6. Advantages of wood
- II. Concrete
  - 1. Advantages
  - 2. Composition
  - 3. Uses in building houses
  - 4. Other uses
- III. Bricks
  - 1. Advantages
  - 2. Methods of making
  - 3. Types of brick houses
  - 4. Brick bond
- IV. Building-stones
  - 1. Kinds of stones used
  - 2. Weathering of stones
- V. Paints
  - 1. Uses and composition
    - *a.* Pigments
    - *b.* Other ingredients
  - 2. Preparing the surface
  - 3. Applying the paint
  - 4. Theory of color

QUESTIONS FOR CLASS DISCUSSION

1. Which makes a better building material, concrete or bricks? Why?
2. Why is wood the most commonly used building material?
3. What are the advantages of each kind of material?
4. What are the objections to each kind of material?
5. Compare bricks with building-stones.
6. How does paint protect the surface to which it is applied?

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CHAPTER II

HEATING THE HOME

1. In what ways are our present methods of heating better than those used in early times?

2. What advantages has each of the following methods of heating the home: hot air, hot water, and steam?

EARLY METHODS OF HEATING

People have become so accustomed to the methods now used to heat their homes that perhaps they do not stop to think that a hundred years ago people did not have the conveniences for heating that we now enjoy. Our present methods of heating, as well as numerous other conveniences, have come to us only gradually, after many changes and improvements running back hundreds of years. Let us consider briefly the changes in methods of heating that have taken place from the very earliest times up to the present day.

Many centuries ago primitive man first built a fire on the earth floor of his crude hut and allowed the smoke to escape through a hole in the top of the hut. As a result of the use of this crude method, the hut was filled with smoke during much of the time. This method was probably used for thousands of years.

The primitive fireplace. When the first chimney was built, the fire was moved to one side of the room, a hole was cut in the wall just over it, and a hood was made that projected out over the fire to collect the smoke. A little later, this plan was improved by making an opening in the wall for the fireplace and by building a separate chimney to carry off the smoke. By the end of the fifteenth century, these fireplaces were in common use throughout the civilized world. For two hundred years after the white people settled this country, they depended entirely upon the open fireplace to warm their homes during the cold winters. In the early days the churches were not heated at all.

Primitive stoves. The next improvement in heating was the invention of the stove. At first it consisted simply of an iron box provided with openings at the top for the escape of the smoke, which passed out into the room. Charcoal was often burned in it, as that did not give off much smoke. The next improvement was the use of a pipe connected with this box to carry the smoke outdoors. The first stove of this type was made about two hundred years ago.

Stoves were first used in this country about fifty years before the Revolutionary War. About thirty-five years before this war, Benjamin Franklin invented (in 1742) the stove that was named after him. The Franklin stove was a box with metal sides, entirely open in front. It was set in the fireplace and connected with the flue of the chimney. This stove was a great improvement over the fireplace. Other improvements have since been made until the modern stove that we use today was developed.

The next great advance made in heating was the plan of placing a single large stove, called a furnace, in the cellar and heating the entire house by means of this. The first furnaces were used only about one hundred years ago.

MODERN METHODS OF HEATING

The modern fireplace. Fireplaces are still frequently built into houses, both because they are ornamental and because the open fire is attractive. During the late spring and the early autumn, when it is not cold enough to start the furnace, these fireplaces serve a useful purpose in taking off the chill during the evening; but as a means of heating, the fireplace is inefficient and expensive. It is inefficient because it raises the air near it to an extremely high temperature, while the air in distant parts of the room is heated only slightly; it is expensive because much heat is wasted in the heated air that passes up the chimney, and because a large amount of fuel is required to keep the fire going. It is not adapted to cold climates.

The modern stove. The stove is a great improvement on the fireplace in that it warms the room more satisfactorily and requires less fuel. The stove heats the room by a process called convection, in which the heated air over the stove rises and circulates to other parts of the room, while the colder air rushes in over the stove and is heated in turn. By this means a larger part of the air of a room is heated than would be possible by the use of a fireplace.

While in the fireplace the fuel is burned in the open, frequently filling the room with smoke, in the stove the fuel is burned in a closed firebox with a special pipe for carrying off the smoke. The stove has the further advantage that it is provided with dampers by means of which the fire may be controlled. When coal is first put into the stove, the back damper should be opened to allow the escape of poisonous gases that form, as otherwise these may be forced back into the room. Cookstoves are so designed that the heated gases are forced to pass around the oven, thus heating it before passing up through the pipe and chimney.

One objection to heating with stoves lies in the fact that several stoves are needed to warm the whole house. Hence, so-called central heating systems are now very widely used, in which the whole house is heated from one furnace located in the cellar, the heat being carried to the various rooms by means of either hot air, hot water, or steam.

Hot-air furnace. The hot-air furnace is a large stove surrounded by a metal jacket, with space between to allow air to circulate. Cold air is brought into this inclosed space; and as this air passes over and around the furnace, it becomes heated. The hot-air furnace is so constructed as to give a large heating surface. From the top of the air-jacket, large pipes or ducts lead to the several rooms and conduct the hot air through registers placed either in the floor or on the walls near the floor. Frequently these pipes or ducts are covered with asbestos to reduce the loss of heat. In each pipe there is usually a damper near the furnace, and in each room there is a register that may be opened or closed, by means of which the hot-air supply may be shut off from one part of the house and sent to other rooms.

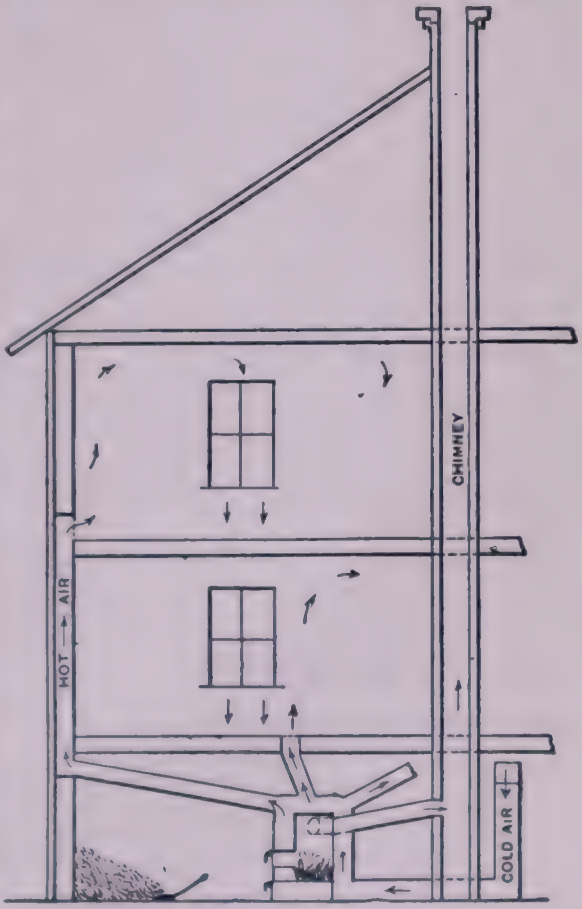

Fig. 9. — Hot-air system

Sources of air. The air that is brought to the furnace to be heated may come from several sources. It may be brought from outdoors by means of a specially constructed pipe leading to the furnace; it may be taken directly from the cellar; or, finally, it may be brought down directly from the rooms above to the furnace to be heated again and recirculated. In this case there are two sets of pipes or ducts, one taking the air from the furnace to the rooms and another set bringing the air from the rooms back to the furnace. The advantage of this last method is that it requires less fuel to heat this air than to heat the cold air from outdoors.

In order to make space for the air which comes into the rooms through the registers, something must be done with the air already there. As previously explained, in the recirculating system the air is led back to the furnace by means of pipes. Sometimes the air is taken out of the rooms through a fireplace or by a specially made flue in the chimney. If no special plan is made for removing the air, it is forced out through cracks around the windows and doors.

One-pipe furnace. A form of furnace known as the pipeless furnace is sometimes used. This is better called the one-pipe furnace. As the name suggests, one large pipe opens into the room above the furnace; and the other rooms are heated from this same pipe by means of open doors or registers. This arrangement is cheap to install and may prove fairly satisfactory for a small house, but is not successful in a house of average size, especially in the colder sections of the country.

The circulation of air through these pipes or ducts is maintained through the effect of heat on gases. When air is heated, it expands and hence becomes lighter; while the air coming in from outdoors is colder and heavier. When two gases of unequal weight are brought into contact, the tendency is for the heavier body to sink to the bottom and push the lighter gas up. Following the same principle in the hot-air furnace, the cold air rushes in under the warm air, which is thus forced upwards.

Demonstration 3

Purpose. To study the principles applied in the hot-air furnace.

Apparatus. Flask; rubber stopper with one hole; glass tubing about a foot long; alcohol lamp or Bunsen burner; tumbler; chimney; piece of cloth; candle.

Directions. 1. Push the glass tubing through the hole in the stopper and insert the stopper in the flask. Fill the tumbler with water and place the end of the tube in it. Heat the flask gently and notice what happens at the end of the tube. What is the explanation? Remove the lamp, but allow the end of the tube to remain in the water. Explain what happens.

2. Light a candle. On the table on each side of the candle put a match; on the matches place a lamp chimney. Light a piece of cloth and hold at the lower end of the chimney near the matches. What do you notice inside the chimney? What does this show?

3. How are the principles illustrated by these two experiments applied in the hot-air furnace?

The hot-water system. In the hot-water system the water is heated in the basement by means of a furnace and is then conducted through pipes to radiators situated in the various rooms. (See figure 10.) In the attic is an expansion tank connected with this set of pipes. The hot water passes to this tank and to the radiators, and then back to the furnace, where it is heated again. Two sets of pipes are necessary for each radiator, one to carry the water to the radiator and another to lead it back to the boiler.

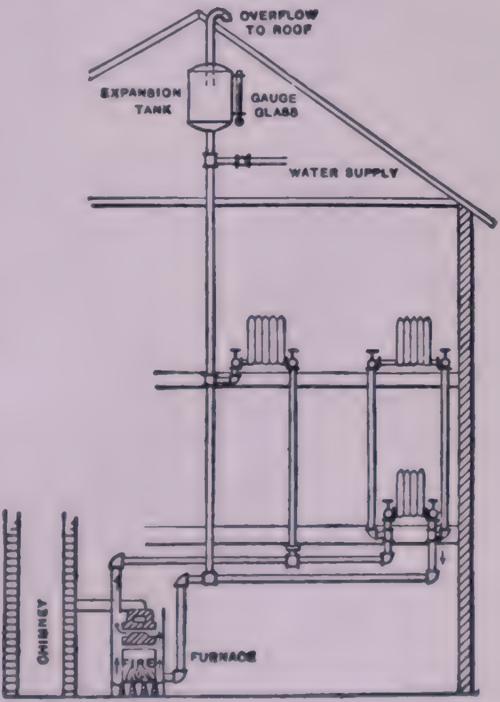

Fig. 10. — Hot-water system

Expansion tank. The expansion tank serves several purposes: It takes care of the increased volume of water due to heating; it furnishes water to keep the system filled when the water contracts on account of cooling; and finally, in case of leakage from the pipes, it furnishes water to take the place of that lost and thus keeps the pipes filled.

Low- and high-pressure systems. Two types of systems are used: the low-pressure system and the high-pressure system. In the former system the tank is open to the air, and the temperature of the water does not get above its boiling point (212°). In the high-pressure system the tank is closed, and the water may be raised under pressure to a temperature above 212°. Thus the efficiency of the radiators is increased because they are raised to a higher temperature.

Air vents. Each radiator must be provided with an air vent to enable the air to escape when the radiator is first filled with water. These vents are of two types, the hand-controlled and the automatic. In the automatic type the vent contains some material which does not quite fill the opening when cold, but which, as it becomes heated, expands and thus closes the outlet.

The explanation of the circulation of the water is similar to that of the circulation of the air in the hot-air system. When water is heated, it expands and becomes lighter and is pushed up by the cold water, which descends to the furnace where it is heated; thus a constant circulation of water is kept up through the pipes. This is called the direct method of heating.

In another method of heating, the coils containing the hot water are placed in the basement; and fresh air from outside is drawn in and heated by these coils and then distributed to the various rooms by means of pipes and registers, as in the hot-air system. This is called the indirect method of heating (see figure 13). This system has an advantage over the direct method in that it provides better ventilation.

In still another system the radiators are placed in each room as in the direct method, and an opening from outside near the radiators brings in fresh air, which is heated by passing over the radiators. This is called the direct-indirect method (see figure 14).

DEMONSTRATION 4

Purpose. To study the principles applied in hot-water heating.

Apparatus. Flask, stopper, and tube used in previous experiment; two flasks with two-hole rubber stoppers; two pieces of glass tubing about ten inches long.

Directions. 1. Fill the flask with water and insert the stopper so that water stands in the tube about an inch from the stopper. Tie a colored string around the tube at the surface of the water. Heat the flask and watch the liquid in the tube. Remove the lamp and allow the water to cool. What happens to the water in the tube in each case? What does this result show?

2. Secure two flasks, one a little smaller than the other. Break a hole in the bottom of the smaller one. Fill the larger flask with water and insert a rubber stopper with two holes. Through these holes push two pieces of glass tubing, one about ten inches long, the other about fifteen. Push the short tube until it just passes through the stopper. Push the other tube nearly to the bottom of the flask. Invert the other flask, insert a rubber stopper with two holes, and into these push the ends of the glass tubes. Add water until the upper ends of the tubes are covered. Add a few drops of red ink. Heat the lower flask and notice the circulation of the water.

3. How are the principles illustrated in these two experiments applied in the hot-water heating?

Steam heating. The method of heating by steam is similar to the hot-water method except that steam instead of hot water circulates through the pipes. There is a similar system of radiators provided with air vents and connected by pipes with the furnace. At the furnace the boilers are so arranged that the water is changed into steam, which then circulates through the pipes. The boiler has three attachments: a water gauge by means of which the level of the water may be determined, a pressure gauge which indicates the steam pressure, and a safety valve to protect the system from danger of too high pressure.

The heating power of the steam is due not alone to the fact that the steam is hot, but largely to the fact that when steam condenses it gives off a large amount of heat. When water is boiled, much heat is required to change it into steam. When we wish to measure the amount of heat, we use a unit called the calorie, just as we use the pound to measure weight. A calorie represents the amount of heat necessary to raise the temperature of one gram of water one degree Centigrade. It requires over five hundred calories to change one gram of water into steam — over five times the amount of heat that is needed to bring water from the freezing point to the boiling point. This heat is stored up in the steam; when the steam condenses, the heat is given out to surrounding objects. While in the hot-water system the heat is given off through the cooling of the water, in the steam system the heat is given off through the condensation of the steam into water. Provision is made for pipes to take the water thus formed back to the furnace.

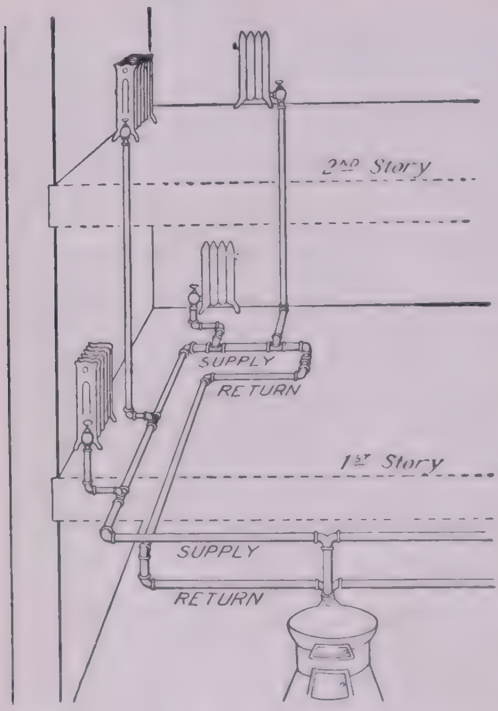

Fig. 11. — A steam-heating system

This return of water may be brought about in two ways — by means of the one-pipe system or of the two-pipe system. In the one-pipe system the water is taken back to the furnace through the same pipe that leads the steam to the radiator. In the two-pipe system the steam passes through one pipe, and the condensed water returns to the furnace through a separate pipe. Sometimes a combination of the two systems is used; the two-pipe system is used for the horizontal pipes, and the one-pipe system for the vertical pipes. The one-pipe system proves satisfactory for small buildings, but for large buildings the two-pipe system is much better. (See figure 11.)

The "hammering" of the pipes so common in the steam system occurs in connection with this condensation of the steam and the resulting motion of the water against the pipes on account of the vacuum thus formed.

DEMONSTRATION 5

Purpose. To learn the source of heat in the steam-heating system.

Apparatus. Flask; rubber stopper with one hole; piece of glass tubing about eighteen inches long; beaker; ring stand; thermometer.

Directions. 1. Bend the tubing twice at right angles so that the two arms are parallel. One of these arms should be about three inches long, and the other arm about eight inches long.

2. Fill the flask a third full of water and insert a rubber stopper with one hole. Push the short arm of the tubing through the hole in the stopper. Support the flask on a ring stand.

3. Fill a beaker with cold water and weigh it. Place it so that the long arm of the tubing dips below the surface of the water in the beaker. Take the temperature of the water. Heat the water in the flask.

4. After it has boiled five minutes, again take the temperature of the water in the beaker. How much has the temperature been raised? Weigh the beaker. How much hot water was added? What was the source of this heat?

HOME PROJECT 1

Purpose. To make a study of the heating system used in your home.

Directions. 1. If your house is heated by hot air, steam, or hot water, make a careful study of the different parts of the system. Begin with the furnace and notice where the various pipes lead, and trace the circulation of air, water, or steam through the house and back to the furnace. Make a drawing of a section of the house from the garret to the cellar, showing the different parts of the system in their proper position.

2. Make a study of a cookstove when there is no fire in it, so that it can be taken apart. Make a drawing of a cross section of the stove. Label in the drawing the following parts: ash pan, grate, draft damper, oven damper, oven clean-out. By means of black arrows show how the smoke and other products of burning pass around the oven and up the flue when

the oven damper is up. By means of red arrows show the path when the damper is down. Notice how the stove may be cleaned out.

Comparison of systems. The advantages and disadvantages of each system are shown briefly in the following table.

KIND OF SYSTEM	ADVANTAGES	DISADVANTAGES
Hot-air furnace	1. Cheap to install 2. Heats up quickly 3. No danger from freezing 4. Provides a change of air 5. Easy to run 6. No space taken up by radiators 7. Adapted to mild weather	1. Danger from coal gas 2. Efficiency depends on wind 3 Brings dirt and dust to rooms 4. Expensive to operate
Hot-water system	1. Gives even temperature 2. Adapted to mild weather 3. Economical to run 4. No dust	1. Danger of freezing 2. No provision for change of air 3. Expensive to install 4. Takes space for radiators 5. Slow changes of temperature
Steam system	1. Adapted to large buildings 2. Economical to run 3. No dust	1. Not adapted to mild weather 2. Difficult to run 3. Sometimes noisy 4. No provision for change of air 5. Expensive to install 6. Takes space for radiators

Distribution of heat. Heat may be distributed in three ways: by convection, by conduction, and by radiation. In convection, heated material moves from place to place carrying its heat with it, as the hot air that rises through the register of a hot-air heating system. In conduction, heat is carried slowly from one object to another object at a lower temperature and in contact with it; for example, when a person touches a hot stove. Heat may also pass from one part to another part of the same object if the two portions are at different temperatures; for instance, if one end of an iron rod is placed in the fire, after a while the other end also becomes hot. In the process of radiation, heat is transmitted from one body to another without heating the medium through which it passes. For example, heat passes from the sun to the earth by radiation. In a similar manner, heat passes from an electric light bulb to a hand or other object held near it.

We may now examine the various methods used in heating the home to see by what means the heat is distributed in each method. In the case of the stove, convection currents are set up over the stove, by means of which heated air is carried to the various parts of the room; and some heat is distributed also by radiation. In the hot-air system, heated air is brought from over the furnace to the rooms by convection. In the hot-water system, hot water is brought to the radiators by convection; the water heats the radiators by conduction; and the radiators in turn heat the air in the room by convection and radiation. In the steam system, the method is similar to that in the hot-water system except that the radiators are heated by steam instead of hot water.

CHEMISTRY OF BURNING

Conditions for burning. The source of heat in any of these systems is the burning of the fuel. In coal the chief element is carbon. In wood, too, this is found, together with other elements including a gas called hydrogen which also burns. The burning of coal consists of the union of the oxygen of the air with the carbon of the coal, forming an invisible gas called carbon dioxide, and consists to a lesser extent of a union of oxygen with hydrogen, forming water. In breathing we give off the carbon dioxide gas which is formed in our bodies in a similar way, but not so rapidly, by the union of oxygen and carbon. This process of uniting with oxygen, called oxidation, takes place in all ordinary types of burning, as in the candle, the kerosene lamp, and the stove.

Before a substance will burn, it must be heated to a certain point called the kindling temperature. In starting fires, substances with a low kindling temperature, such as paper, are used first; this then sets fire to a substance with a higher kindling temperature, such as wood; and finally the wood in burning heats up a substance with a still higher kindling temperature, such as hard coal, till it, too, burns.

Kinds of fuels. Fuels may be divided into three classes: solid, such as coal; liquid, such as kerosene; and gas, such as illuminating gas.

Oil. While the solid fuels have been used most commonly in the past, liquid fuels have been coming into use during recent years. Quite a variety of oil burners are now for sale which burn kerosene or a cheaper oil. These burners are installed inside the ordinary fire box of a furnace, the rest of the heating system remaining unchanged. There are all sorts of burners, from the very simple to the very complicated. While some of these burners have proved failures, there are other types that work satisfactorily. The simplest types consist merely of a device for vaporizing the oil before it is burned. The more expensive types add blowers, pilot lights, automatic controls, and safety devices. The great advantages claimed for these oil burners are cleanliness and ease of operation.

Coal. The kinds of solid fuel most commonly used are the following: coal, coke, briquettes, and wood. Coals are divided into two broad classes—the hard and the soft. The hard coal contains a larger percentage of carbon than does the soft coal, which contains more of certain substances that are driven off when the coal is heated. These substances are not completely burned, and as a result a large amount of smoke is formed when soft coal is used. Hard coal, in accordance with its size, is divided into the following grades, the largest being named first: egg, stove, chestnut, pea, and buckwheat.

Coke. Coke, which is obtained from the distillation of coal, is an excellent fuel. It burns without much flame and produces an intense heat. Since it is porous, it occupies a larger volume than does the same weight of coal.

Briquettes. The increase in the price of coal has led to the use of briquettes. These are made by compressing coal dust or sawdust into blocks of a size suitable for handling as a fuel. Sometimes a binder is used to hold the particles together.

With all types of fuels, the important part of the air in the process of burning is oxygen, which makes up about one fifth of the air. The following experiment shows some properties of pure oxygen when unmixed with the nitrogen found in the air.

DEMONSTRATION 6

Purposes. To prepare oxygen and to study its properties.

Apparatus. Bottle with stopper to fit; glass tubing about eighteen inches long; pneumatic trough; four wide-mouthed glass bottles; oxone; sulphur; iron picture-wire; piece of chalk.

Directions. A. *Preparation of oxygen.* 1. Bend the glass tube about three inches from one end to make an acute angle, and at the same distance from the other end bend it to make an obtuse angle. Insert the end with the acute angle in the hole of the stopper and put this in the bottle. Support the bottle on the ring of a ring stand. Place the other end of the tube under the shelf of the pneumatic trough. Fill the trough with water to cover the shelf. Fill four wide-mouthed bottles with water and invert on the shelf.

2. Remove the stopper from the first bottle, put in some oxone, and

add a little water. Quickly insert the stopper. Then place one bottle with the mouth over the opening in the shelf so as to collect the gas. When the water has all been forced out, remove the bottle and put another in its place. In this way fill four bottles.

B. *Properties of oxygen.* 1. Invert one of the bottles and put in it a glowing splint. How does the action compare with that in air? Pour in a little limewater; shake the bottle. The white precipitate shows the presence of carbon dioxide.

2. Fasten a wire to a candle, light the candle, and plunge it into a second bottle. Note results.

3. Scoop out one end of a piece of chalk an inch long. Wind a piece of wire around it. Put some powdered sulphur on this chalk. Ignite it in a flame and then lower it in a third bottle. Note the difference between burning in air and burning in oxygen.

4. Wrap a small piece of cloth around the end of an iron picture-wire. Roll this in powdered sulphur and hold it in the flame. When it has started burning, lower it into a fourth bottle of oxygen.

5. What conclusions do you draw from these experiments regarding the properties of oxygen and the difference between burning in air and in pure oxygen?

DEMONSTRATION 7

Purpose. To study the burning of wood, soft coal, and hard coal.

Apparatus. Ring stand, wire gauze; gas burner or alcohol lamp; small piece of wood; soft coal; hard coal.

Directions. 1. Place a small piece of wood on a wire gauze on a ring stand. Heat the wood. Place the gauze at such a height above the flame that the wood is heated without bursting into a flame. When the wood begins to smoke, hold a lighted match above it. The flame formed is due to the burning of the substances driven off from the wood by the heat. What change takes place in the wood?

The substance left is charcoal. Apply a flame to it and see if it will burn. How does the burning differ from that of the substances in the previous experiment?

2. In a similar way try soft coal, using a piece about as large as the end of your finger.

3. Repeat the experiment, using hard coal. What difference do you note in the burning of the two coals? The substance left after the first heating is coke. Will this burn?

MEANS OF STARTING FIRES

In the early times fires were kindled by rubbing two sticks together. A great improvement was made on this method when sparks were formed by striking flint against a kind of iron ore. This method was commonly used till about a century ago, when matches were first made. When a match is drawn across a rough surface, the friction produces enough heat to set fire to the substance on the tip of the match, which then ignites the wood. Sulphur and phosphorus have been commonly used, because they burn at a low temperature. With these is usually mixed some compound that contains oxygen, which makes the sulphur burn more readily. Until recently yellow phosphorus was one of the substances commonly used to tip matches. This is a dangerous element to handle and has a very injurious effect on the people who make matches, causing a disease of the bones which usually proves serious. The use of this kind of phosphorus has been forbidden by law, and in its place a harmless compound of phosphorus is now used.

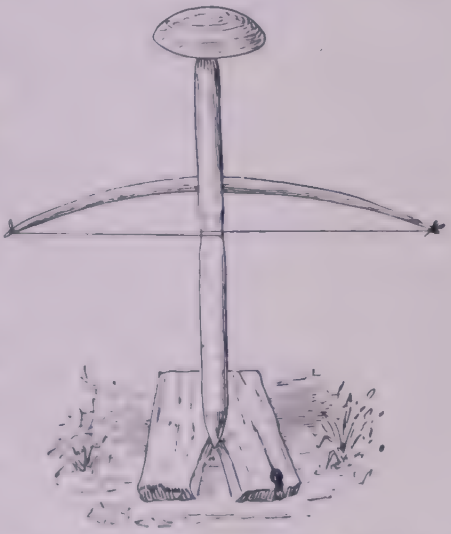

Fig. 12. — Primitive method of making fire by friction

In safety matches the harmless red phosphorus is used. The match can be ignited only by rubbing it on a specially prepared striking-surface. These are much less dangerous than the ordinary matches, as there is less risk of accidental fires. While it may be a little more trouble to use safety matches, this trouble is repaid by the lessened danger from fires. If ordinary matches are used, they should be kept in a glass, earthenware, or metal container.

LABORATORY EXERCISE 4

Purpose. To compare safety matches and ordinary matches.

Apparatus. Safety matches; ordinary matches.

Directions. Notice the parts of an ordinary match. How does a safety match differ? Light an ordinary match and note the order in which each part burns. Do the same with a safety match. Try to light each kind of match on an ordinary board surface. What difference do you find? What advantage has the safety match?

OUTLINE SUMMARY

HEATING THE HOME

I. Early methods of heating
    1. Primitive fireplace
    2. Primitive stoves

II. Modern methods of heating
    1. Modern fireplace
    2. Modern stove
    3. Hot-air furnace
        a. Sources of air
        b. One-pipe furnace
    4. Hot-water system
        a. Expansion tank
        b. Low- and high-pressure systems
        c. Air vents
    5. Steam heating
    6. Comparison of systems
    7. Distribution of heat

III. Chemistry of burning
    1. Conditions for burning
    2. Kinds of fuels
        a. Oil
        b. Coal
        c. Coke
        d. Briquettes

IV. Means of starting fires

QUESTIONS FOR CLASS DISCUSSION

1. Why are fireplaces still used?
2. Why is the stove superior to the fireplace as a means of heating?
3. What principles of physics are applied in each of the methods used in heating our homes?
4. What are the chief differences between the hot-water and the steam method of heating?

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CHAPTER III

VENTILATING THE HOME

1. What are the essentials for a good system of ventilation?

2. From the standpoint of the ventilation provided, which is the best heating system?

By ventilation is meant the keeping of the air in which we live in such a condition that it will be healthful to our bodies. The problems of heating and ventilating the home should be considered together, because the method of ventilation depends on the method of heating and should be arranged for when the heating system is put in. Much can be done later to ventilate the house, however, even if no provision was made for it when the house was built.

DEMONSTRATION 8

Purpose. To study the composition of air.

Apparatus. Candle; cork; plate; tumbler; limewater.

Directions. 1. Get a cork stopper a little larger than the diameter of a candle. Cut from the large end a piece about half an inch thick. In the center cut a hole big enough to receive a short candle about an inch long. Float this in a plateful of water. The experiment can be seen better if a few drops of red ink are added to the water. Light the candle and, after it is burning well, invert the glass tumbler over it. Allow to stand for a while after the candle goes out. Why does the candle go out? What happens to the water in the tumbler? The water rises to take the place of the oxygen used by the candle. The gas left in the tumbler is nitrogen. What are the proportions of oxygen and nitrogen in the air?

2. To show the presence of carbon dioxide, pour some limewater into a dish and allow it to stand for an hour or two. The white coating that forms on the surface of the water shows the presence of carbon dioxide.

3. To show the presence of water in the air. Bring into the schoolroom a metal cup containing a mixture of ice and salt. What is the source of the water that condenses on the outside of the cup?

DEMONSTRATION 9

Purpose. To learn how the air we breathe out differs from the air we breathe in.

Apparatus. Thermometer; limewater; straw; bicycle pump.

Directions. 1. Breathe on the bulb of a thermometer and compare the temperature with that of the room.

2. Pour some limewater into a test tube and blow through it by means of a straw or a glass tube. Pour limewater into another tube and force air through by means of a bicycle pump. Which solution gets the milkier? What does this difference show?

3. Breathe on a window pane. What do the results show?

4. Remove the covers of two quart canning jars. Allow one jar to stand outdoors. Have a pupil breathe into the other by means of a glass tube. Screw the covers on both jars tightly and let them stand in a warm place for a day or two. Just after the children have come in from outdoors, have the pupil who breathed into the bottle smell of the air in both bottles. What difference is noted? What does this experiment show?

5. What four changes have taken place in the air we breathe out?

BREATHING

The air is made up of about one fifth oxygen, four fifths nitrogen, a small fraction of one per cent of carbon dioxide, and minute quantities of other gases; and it also contains varying amounts of invisible water vapor. In the process of breathing, the air is taken into the lungs, and the oxygen is taken by the blood to all parts of the body. Here it unites with the food that has been digested and absorbed; and burning takes place slowly, in much the same way that coal and wood burn in the stove, only much less rapidly and without giving off light.

As a result of this slow burning or oxidation, the body is kept warm and power is given to use the muscles. In this process of oxidation, carbon dioxide is formed and carried back by the blood to the lungs, from which it is exhaled. As a result of this process of breathing, the oxygen in the air has been reduced from 21 per cent to 16 per cent; and there has been an increase in the amounts of water and of carbon dioxide.

ILL EFFECTS OF LACK OF VENTILATION

The ill effects of lack of ventilation, as frequently shown in crowded rooms and lecture halls, are well known. Drowsiness, fatigue, lack of attention, headache, and a general feeling of unpleasantness are the results. In winter, colds and similar illnesses are common results of lack of proper ventilation. The ill effects on those who are obliged to work for long periods of time in poorly ventilated rooms are shown on every hand, especially by contrast with those who work outdoors. There is a tendency toward a general weakening of the body, which may eventually develop into tuberculosis and other lung troubles, while those who are much in the open are healthier and much less likely to contract these diseases.

Chemical causes of ill effects. In order to know how to ventilate properly, we need to learn what are the causes of these ill effects, so that we may know what to seek and what to avoid. Two classes of causes have been suggested at various times—the chemical and the physical. As the air undergoes chemical changes in the process of breathing, the early theory claimed that the injurious effects of bad air were due either to lack of oxygen or to an excess of carbon dioxide. But experiments have shown that neither of these conditions is the cause, since under ordinary circumstances practically all air contains enough oxygen for breathing, and practically no air contains enough carbon dioxide to be injurious.

Another explanation maintained that the ill effects were produced by tiny particles given off in breathing; but experiments seem to show that these are not the cause. However, disagreeable odors, due to particles given off from the body, from decaying teeth, and from clothing, render the air very unpleasant and may at times produce injurious results.

Physical causes of ill effects. The cause of the ill effects of poor ventilation is thus seen not to lie in the lack of chemical purity of the air, but must be sought in its physical conditions. Ventilation is not merely a matter of breathing, but is also a matter of the reaction of the skin to the air, with which it is in constant contact.

Recent experiments show that in seeking the essentials of ventilation we should consider the effect of the air on our skin rather than the effect on our lungs of the air we breathe.

HOW THE BODY CONTROLS ITS TEMPERATURE

In order to understand what is needed for ventilation, one must know something of the part that the skin plays in controlling the heat of the body. Heat is produced in the body by the oxidation of food. The body is provided with means by which its temperature is automatically kept uniform (about 98 degrees). There are two methods by which the body loses heat: first, by sending large quantities of blood to the surface of the skin, where it is cooled; and second, by the evaporation of water from the pores of the skin in perspiration.

If the body is too warm, the arteries in the skin open wide and thus allow large amounts of blood to come to the skin, where cooling takes place; and the sweat glands increase their activity in evaporating water. On the other hand, if the body is too cool, the activity of the sweat glands is lessened and the arteries contract, with the result that less blood is sent to the skin.

The ill effects of lack of ventilation are due largely to interference with this heat-regulating device. Recent experiments show that these ill effects are due chiefly to four causes: (1) lack of air currents; (2) too high temperature; (3) too little or too much moisture in the air; (4) unpleasant odors.

ESSENTIALS OF VENTILATION

A proper system of ventilation should therefore meet these conditions:

1. It should furnish a gentle current of air.
2. It should heat this air to the proper temperature, not to exceed 70 degrees.
3. It should add moisture to bring the air up to the proper degree of humidity, from 50 to 60 per cent.
4. It should change the air so as to keep it free from disagreeable odors.

Air currents. One of the most satisfactory methods of producing an air current is to use the indirect method of heating, by which the air is first heated in the basement and then brought into the rooms. This is the method used in the hot-air furnace and in the indirect method of the hot-water and steam systems. By this method of heating, the air is necessarily kept in motion. In the direct method of heating, in which radiators are placed in the rooms, the circulation of air is not satisfactory, since it is limited chiefly to the region near the radiators.

The common notion that drafts are injurious is a mistake, as they are essential to good ventilation. You do not take cold when out in the wind if you are properly clothed. When sitting indoors, it is well to guard against exposing a small part of the body to a very cold, strong draft; but some motion of air is essential to our comfort and health. If there is no movement of air, the layer of air next to the skin becomes warm and full of moisture. As a result, evaporation is lessened and the body becomes uncomfortably warm.

Colds and similar kinds of sickness, which are so common during the winter, are usually not due to exposure to drafts, as is often thought, but are due generally to the unhealthful condition of a hot, dry, motionless air that too often exists indoors during the cold season. As a result the body becomes more susceptible to the action of the bacteria that cause colds. The remedy for these ills is to remove the condition that causes them.

DEMONSTRATION 10

Purpose. To learn the conditions necessary for a change of air in ventilation.

Apparatus. Candle; lamp chimney with even top; two matches; cardboard.

Directions. 1. Light the candle. Place the chimney over it. Why does the candle go out?

2. Light the candle again. On each side, place a match. On the matches place the chimney, and cover the top with the cardboard. Why does the candle go out now?

3. Repeat the previous experiment, except that the cardboard is not placed over the chimney. Why does the candle continue to burn?

4. What do these experiments show?

Temperature. If the temperature is too high, the body makes extra exertion by means of the sweat glands and blood vessels to lower the temperature. As a result, the blood is drawn to the surface from other parts of the body. One of the common causes of ill effects from poor ventilation is too high a temperature. It has been proved that the most healthful temperature for the living rooms is between 65 and 70 degrees. When the temperature becomes higher than 70, it produces unpleasant feelings and makes work more difficult.

The temperature at which one feels comfortable depends on the humidity — that is, the amount of moisture in the air. With the low degree of humidity usually found in our houses, about 68 degrees is the best temperature. But if enough moisture is added to raise the humidity to 50 or 60 per cent, one will feel just as comfortable at 65 degrees. The best temperature depends also on the occupation and dress of the people living in the room.

The temperature may be noted easily by means of a thermometer. This consists of a glass tube with a very small bore and with a bulb at one end filled with mercury or some colored liquid, usually alcohol, which does not freeze at ordinary temperatures. In making a thermometer, the air is removed from the bore above the liquid, so that there is nothing left to interfere with the motion of the liquid. Heat causes the liquid to expand and to rise in the bore, which is marked off into degrees. In the common Fahrenheit thermometer, the freezing point of water is marked 32 degrees and the boiling point 212 degrees, and the space between is divided into 180 degrees. In the Centigrade thermometer, the freezing point is marked 0 and the boiling point 100, and the space between is divided into 100 degrees. The Centigrade is much more convenient and is widely used in Europe for general purposes and in this country for scientific work.

LABORATORY EXERCISE 5

Purpose. To study and test thermometers.

Apparatus. Fahrenheit thermometer; Centigrade thermometer; beaker or tumbler; ice.

Directions. 1. Make drawings, side by side, of a Fahrenheit and a Centigrade thermometer. In each drawing, mark the following points: the freezing point of water; the boiling point of water (this may not appear on some thermometers); the temperature of the body (hold finger on bulb or breathe on it; the result will be only approximate, as the liquid will not rise quite to the body temperature); the proper living temperature of the schoolroom in winter.

Into how many degrees is the space between the freezing and boiling points marked on each scale? What advantage do you think the Centigrade scale has over the Fahrenheit? Do you see any disadvantage?

2. The thermometers found in houses are often incorrect. Bring yours from home so that you can test it. Place the end of the thermometer in a tumbler and fill the tumbler with cracked ice. Allow it to stand till the water from the melted ice covers the bulb and the liquid in the thermometer falls no lower. Record the reading. The correct reading is 32. Hang up

your thermometer beside a tested chemical thermometer furnished by the instructor. Note the difference. The average of this difference and of the error at the freezing point may be taken as the correction to be made in using your thermometer.

Humidity. If the air is too moist, evaporation in the skin takes place slowly and the body becomes too warm. If the air contains too little moisture, evaporation takes place too rapidly. The lack of moisture in the heated air in our homes in winter has an injurious effect on the nose and throat. As this dry air passes over the membrane lining the nose and throat, it causes an excessive amount of evaporation from these surfaces, which become dry, parched, and irritated. As a result they afford a lodging place for germs, and we become more easily subject to colds and other diseases of the throat and nose. Furthermore these membranes are not able to do so well their ordinary work of filtering the air.

This extreme dryness found indoors during the winter produces an artificial and unnatural condition because it is such a contrast to the natural condition found outdoors.

The amount of moisture in the air is measured in terms of per cent. When the air is saturated (that is, holds all it can, as just before a rain), the humidity of the air is said to be 100 per cent. If it holds one half as much moisture as it could contain, the humidity is said to be 50 per cent. Outdoors in most sections of the United States the humidity ranges from 65 to 75 per cent or more. Indoors during the winter in the ordinary heated room, it is found that the humidity is often very low, ranging from 20 to 30 per cent.

During the winter the air taken into the heating system from outdoors is very cold; and as it is heated, its power to hold more moisture increases rapidly, doubling for about each 20 degrees: thus air, which at a temperature of 30 degrees may be half saturated, at 70 degrees will be only about one eighth saturated, and hence will be very dry and possess great absorbing power. This humidity may be raised by introducing water into the hot-air chamber in the cellar. Many of the water pans often found in hot-air furnaces are worthless, because they do not add enough moisture to affect the humidity appreciably.

In order to furnish enough moisture for an ordinary house, from one to two quarts of water should be evaporated hourly. There are now sold on the market instruments which can be used to supply the necessary water.

DEMONSTRATION 11

Purpose. To find the humidity of the room.

Apparatus. Two thermometers, or a sling psychrometer.

Directions. 1. Fasten a piece of soft muslin cloth around the bulb of one of the thermometers and allow the other end of the cloth to hang in a bottle filled with water. Hang another thermometer beside this. Fan the bulbs vigorously for a short time; then look at the reading of the wet bulb. Continue to fan until the mercury in the wet bulb ceases to go any lower. Then take the reading of both the thermometers. A slight difference means a moist air. A large difference means a dry air. The per cent of humidity may be found from the table on page 569. For example, if the difference between the two thermometers is 16 degrees and the reading of the dry bulb is 70 degrees, the figure opposite 16 and under 70 gives the percentage of humidity — in this case, 33. Find the humidity of the air outdoors.

2. If a sling psychrometer is available, the test can be made more quickly and accurately.

COMPARISON OF HEATING SYSTEMS

We may now examine the various systems of heating with reference to the provision they make for ventilation. The hot-water and steam heating systems, as ordinarily installed with radiators in each room, are the poorest, as no provision is made for change of air. The hot-air furnace, when fresh air is taken from outside, is preferable, as it provides for a change of air.

If there is only one opening — the register where the hot air enters — some ventilation is provided, since some air is forced out around the windows; but in the best systems, an opening to a flue in the chimney is provided by means of which the used air is taken away.

If properly installed, the hot-water system is probably the best. To provide for change of air, coils of pipe are placed in the basement. Fresh air is led from outdoors over these pipes, where it is heated. It can then be distributed to the rooms above by means of hot-air pipes, in a manner similar to that used with the hot-air furnace. Ventilation may be secured also by bringing the air directly from outdoors and allowing it to pass over a radiator. (See figure 14.)

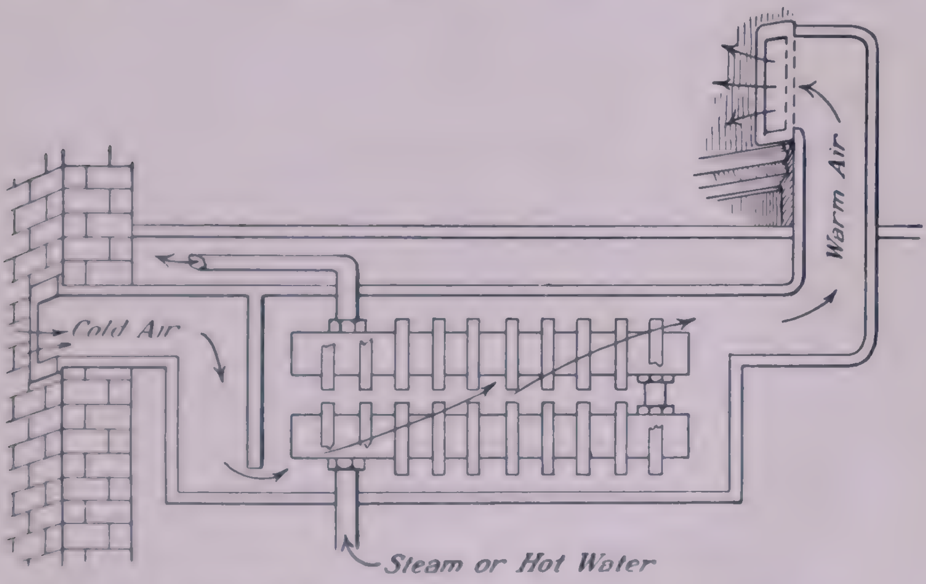

Fig. 13. — A method of ventilation in steam and hot-water systems

The open fireplace provides good ventilation, as air passes up the chimney and fresh air is drawn in from around the windows and doors. The stove provides ventilation in the same way.

Oil stoves and gas stoves are both unhealthful, as they draw the supply of oxygen from the air and give off all their waste products into the same room. As there is no provision for removing them, the air soon becomes filled with these products, some of which have a disagreeable odor.

HOME PROJECT 2

Purpose. To learn whether your home is properly ventilated.

Directions. 1. Is the air kept in motion? Light a piece of punk or cloth and hold it in various parts of the room and at different heights from the floor; notice the direction of air currents as shown by the smoke. Make a drawing of the room and show the direction of currents by means of arrows. Open some windows and test again for air currents. Find out which combination of open windows gives the best circulation of air.

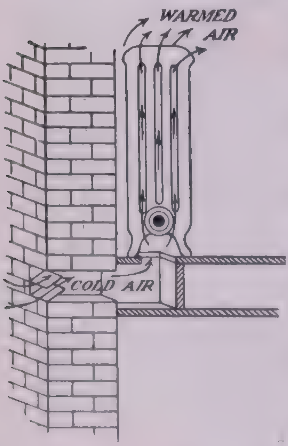

Fig. 14. — Ventilation at the radiator

2. Is a change of air provided? When you first come in from outdoors do you detect odors in the room? Are there any openings through which air enters the room? Does this air come from outdoors, or from the cellar, or is it return air taken from the room? Are there any openings where the impure air can escape?

3. Is the room kept at the proper temperature (from 68° to 70°)? Read the thermometer several times in the day. Place it in different parts of the room and at different heights from the floor and take the readings. Make a record of all the readings in a table like the following.

TEMPERATURE	TIME OF DAY	HEIGHT OF THERMOMETER FROM FLOOR	LOCATION WITH REFERENCE TO SOURCE OF HEAT

4. Is the proper degree of humidity maintained (from 50 to 60 per cent)? Determine the percentage of humidity, using the method explained in Demonstration 11. Find also the humidity outdoors.

5. Which of the four essentials of ventilation are provided in your home? Which ones are not provided? What can be done to provide those essentials that are lacking?

VENTILATION BY WINDOWS

Unfortunately in many of our homes no special provision was made for ventilation when the houses were built; hence we must plan our ventilation as best we can by means of doors and windows. When a system of hot-air heating is used by means of which fresh air is forced into the room, other air must be forced out through these cracks; and thus some ventilation is provided, sufficient perhaps for a small family but not enough for a schoolroom. In the steam or the hot-water system when radiators are placed in the rooms with no provision for bringing in fresh air, the amount of ventilation brought about by means of the cracks around the windows is not sufficient, especially in our modern houses, which are more completely air-tight than older houses. Often, too, in northern climates houses are provided with storm windows, which tend to keep out the fresh air that might otherwise have entered.

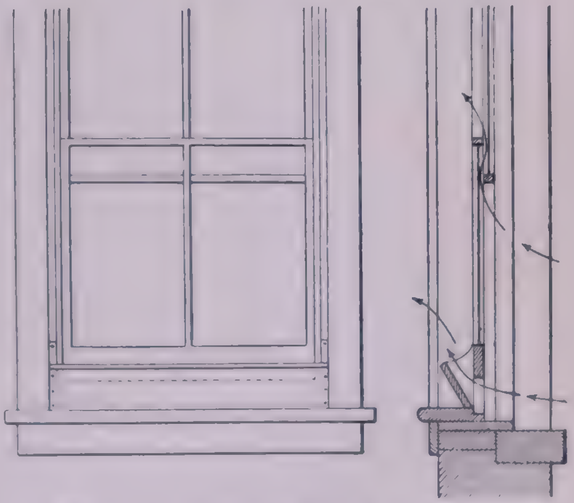

Fig. 15. — Ventilation by window

Ventilation may be secured by opening windows on different sides of a room, and a board may be placed in front of a window to break the strength of the wind. One excellent way of providing ventilation without lowering the temperature is to fit to the lower window a frame like that of a mosquito screen,

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so that the window may be lifted and the frame placed under it. This may be made any height desired and may be covered with ordinary cotton cloth. This allows the fresh air to enter but prevents the room from being suddenly cooled, as the cloth does not lose heat much faster than does the glass in the window.

VENTILATION OF SLEEPING ROOM

Special attention should be given to the ventilation of our sleeping rooms, even in the coldest weather. Fresh air should be provided by opening the windows, and in cold weather we may keep ourselves comfortable by extra blankets. In cold, windy weather, strong drafts may be avoided by placing a chair with a towel or a piece of cloth over it in front of the window; or a board may be placed across the bottom of the window in such

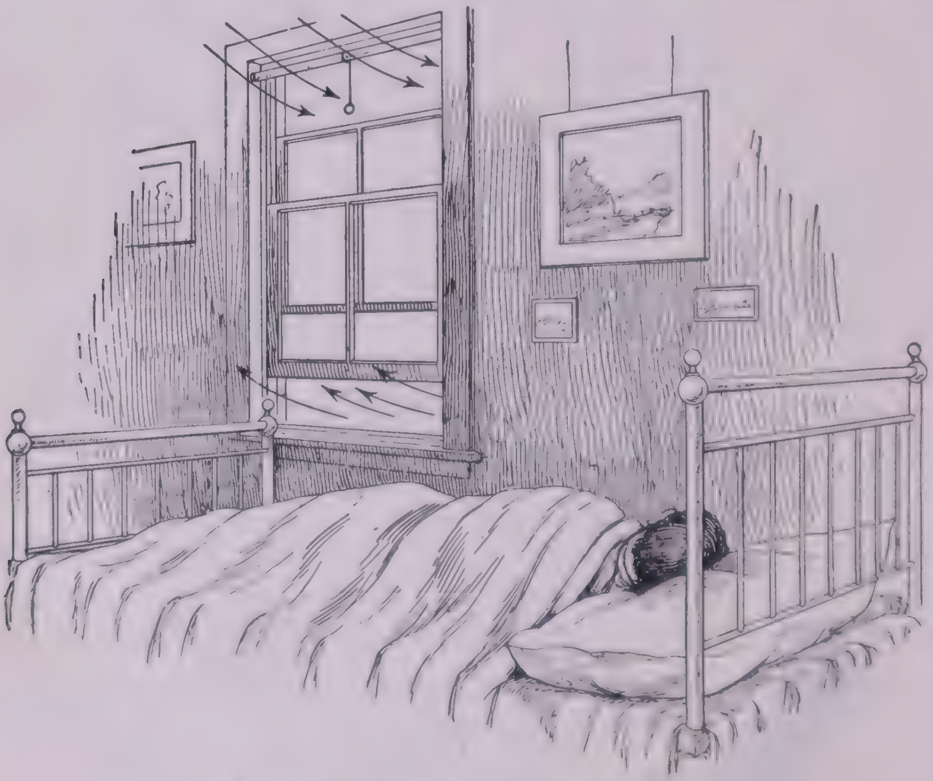

Fig. 16. — Getting fresh air at night

a way that the air will strike this and be directed over the top into the upper part of the room; or the screen ventilator, as mentioned in the previous paragraph, may be used.

HOME PROJECT 3

Purpose. To make a ventilating screen.

Directions. For use in cold weather, make a ventilating screen to fit your bedroom windows. Follow the directions given on pages 51 and 52. Try it and see if it proves satisfactory.

OUTLINE SUMMARY

VENTILATING THE HOME

I. Breathing
II. Ill effects of lack of ventilation
    1. Chemical causes of ill effects
    2. Physical causes of ill effects
III. How the body controls its temperature
IV. Essentials of ventilation
    1. Air currents
    2. Proper temperature
    3. Proper humidity
V. Comparison of heating systems
VI. Ventilation by windows
VII. Ventilation of sleeping room

QUESTIONS FOR CLASS DISCUSSION

1. How does the air we breathe out differ from the air we breathe in?

2. What theories have been advanced to explain the ill effects due to poor ventilation? Which is the correct theory?

3. How does the body control its temperature?

4. Are the essentials of ventilation provided in your home? In the schoolroom?

5. What is the principle involved in the thermometer?

6. What is the relation of humidity to ventilation?

7. Air when heated contains the same amount of water that it contained when cold. Why is the per cent of humidity so much lower?

8. How may one secure ventilation during the night while one is asleep?

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CHAPTER IV

LIGHTING THE HOME

What advantages has each of the methods now used for lighting the home?

As we have seen, methods of heating have gone through many changes, beginning with crude devices used by primitive people. In a similar way methods of lighting have undergone many changes, beginning with the simplest forms used thousands of years ago. Probably the first method of lighting was a torch made by setting fire to the end of a stick. This was probably the only means used for many hundreds of years.

CANDLES

In time crude forms of candles appeared, and these were gradually improved until now we have our modern candle. At first candles were made by hand by dipping a string into melted tallow and allowing it to cool, and then dipping again until the desired size was obtained. Today candles are made by machinery which pours the melted paraffin into a mold through the center of which hangs a string.

In our own country, torches were frequently used by the early settlers. Lincoln learned to read by the light of pine knots. The candle was very widely used even during the first half of the last century.

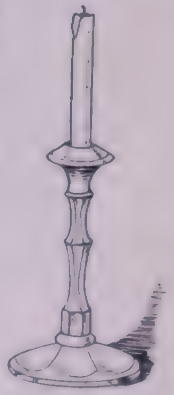


Fig. 17. — Candle in candlestick

Burning of a candle. When the candle is first lighted, the heat melts the paraffin, this liquid is drawn up the wick, the heat then changes the liquid to gas, and the gas burns with a flame. The elements in the gas unite with the oxygen of the air and gases are given off — chiefly carbon dioxide and water vapor. An ordinary flame consists of two parts, a bluish inner portion and a yellowish outer portion. The inner part consists of the unburned gas formed by heating the liquid. The outer part consists of the burning gases. The light of the flame is due to small particles of carbon which become intensely hot and glow, thus giving off light. The yellowish color is due to the presence of small quantities of compounds of a metal called sodium, which is present in minute quantities even on the dust particles of the air.

LABORATORY EXERCISE 6

Purpose. To study the burning of a candle.

Apparatus. Candle; piece of glass or cardboard.

Directions. 1. Light the candle. After it is burning well, light a match, blow out the candle, and then quickly hold the lighted match about a half inch above the candle. Why does it light? Try several times to see how far above the candle you can hold the match and light it.

2. How many parts do you see in the candle flame? What is happening to the paraffin near the wick? Blow out the candle flame and look quickly at the wick and feel of it. What does it contain?

3. Press a piece of glass or cardboard down on the flame and hold it so for a second or two. What is formed on the glass? How is it arranged?

4. Hold a match or a toothpick across the middle of the flame till it begins to burn, then take it away and blow out the flame on the wood. Where does it begin to burn first?

5. What do the last two experiments show regarding the hottest part of the flame?

DEMONSTRATION 12

Purpose. To find out what conditions are needed for a candle to continue burning.

Apparatus. Lamp chimney with level top; limewater; glass tumbler.

Directions. 1. Light the candle. Invert a glass tumbler over it. Why does it go out? Light the candle again. Invert over it a canning jar. Does the candle burn any longer? Why?

2. Light the candle. On each side place a match and on the matches

put the lamp chimney. Place a piece of cardboard on the top of the chimney. Why does the flame go out?

3. Light the candle and place it on a piece of blotting paper. Put the chimney over the candle and hold it down firmly on the blotting paper. Why does the flame go out?

4. Light the candle and place a match on each side. On the matches place the chimney. Does the flame act as in the previous experiments? Why, or why not?

5. What do these experiments show that a candle needs in order to keep burning?

6. To show what is given off when a candle burns, place a candle about an inch long in a glass tumbler. Light the candle and cover the tumbler with a piece of cardboard. After the flame goes out, quickly remove the candle and pour some limewater into the tumbler. Cover the tumbler and shake. The white substance formed shows the presence of carbon dioxide.

LAMPS

Early lamps. Another means of lighting used in early times along with the torch was a crude form of lamp. This consisted of some open receptacle like a shell, filled with oil, in which was placed a wick of some fibrous material. These lamps furnished a very weak and flickering light and gave off much smoke. It was a long time before a chimney was invented. The first lamp with a chimney was made about 125 years ago by a Swiss named Argand.

Various kinds of oils have been used. During the first half of the nineteenth century, whale oil was in common use in this country. This was later replaced by kerosene, which has been in use for only about fifty years.

Kerosene lamps. The kerosene lamp is a great improvement on the candle, as it gives a stronger and steadier light. Kerosene is obtained from petroleum, a thick liquid found in the earth. It contains a great variety of substances, which are separated from each other by heating the petroleum. As this is heated, the various liquids boil and are given off as gases, which are caught and cooled till they condense to liquids again. Those that boil at low temperatures are given off first. These gases are caught in different vessels according to the temperature at which they are given off; and thus the various liquids are separated. Kerosene is one of the liquids that have a high boiling point.

If the oil we burn in lamps should contain liquids that burn at a low temperature, there would be danger of explosion; hence the government requires as a measure of protection that kerosene shall have a flashing point of sufficiently high temperature to be safe under ordinary conditions. The flashing point is the temperature at which a momentary flash is formed when a flame is brought near the oil. The standard set is usually about 110 degrees. The temperature at which a continuous flame would be maintained, which is from forty to fifty degrees higher, is called the burning point.

The principle involved in the burning of kerosene is the same as in the burning of a candle, except that the substance used is a liquid instead of a solid. The heat changes this liquid to a gas, which burns and gives off heat and light. One feature which gives the kerosene lamp a great advantage over the candle is the use of a chimney. This creates a draft which furnishes a constant supply of fresh air to the wick and insures a steady light. In some lamps the wick is made circular, so that the air is supplied from the inside as well as from the outside. In one type of hanging lamp the wick and chimney are so placed on the side that the light is thrown downward.

Capillarity. The process by which the kerosene rises through the wick is called capillarity. Other illustrations of capillarity are seen in the absorption of ink by a blotter and in the rise of water through soils. When water stands in a dish, the water at the side is attracted by the dish and rises slightly, making a curved surface. If the container is so small as to be a tube, the water inside the tube rises higher than the surface outside; and the smaller the tube the higher the water rises. The spaces between the threads of the wick act like small tubes, through which the kerosene rises.

DEMONSTRATION 13

Purpose. To study the structure and workings of a kerosene lamp.

Apparatus. Ordinary kerosene lamp; small tube; plate; two pieces of glass of the same size; rubber band; two tumblers; red ink; lump of sugar; blotting paper.

Directions. 1. Study the structure of the parts of the lamp. What purpose does each part serve?

2. Light the lamp. After it burns for a minute, blow it out and quickly hold a lighted match above the wick. Try several times to see how far above the wick the match can be held and still light the wick. What does this result show?

3. Light the wick and keep the chimney off. Fan the flame gently. Put on the chimney. What difference does it make in the flame? Fan the air near the chimney. How does the effect differ from that when the chimney was off?

4. Push a piece of cloth up under the burner and cover the small holes on the side. What happens? Why?

5. The method by which the oil passes up through the wick is capillarity. A few simple experiments will illustrate this. Put a small tube in water. Compare the level of the water inside with that outside.

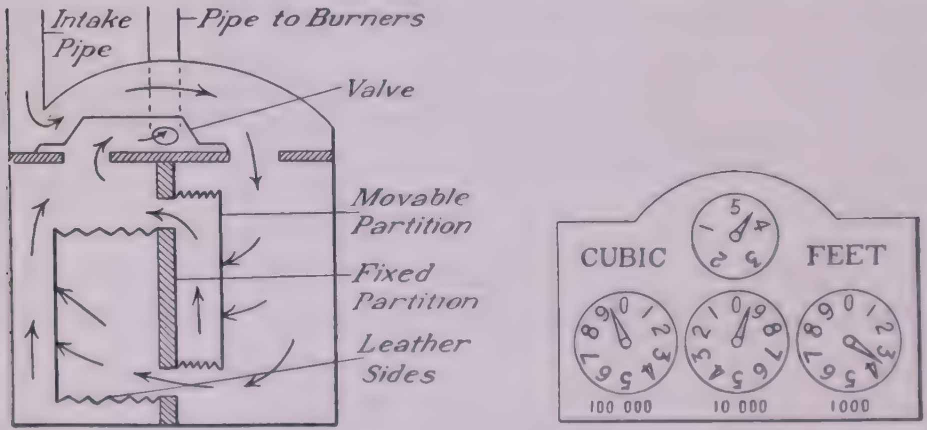
Put some water in a plate and add a little red ink. Place two pieces of glass together and set them on edge in the plate. Separate the two at one edge and insert a piece of toothpick or match. Keep the opposite edges touching by means of a rubber band. Hold the pieces in this position and notice how the water rises between the plates. How do you explain the curve assumed by the water between the pieces of glass?

Put the edge of a piece of blotting paper in ink and see how high the ink will rise. Hold the corner of a lump of sugar in water and note results.

GAS

The use of gas marks another advance in the methods of lighting. The mantle burners give a stronger light than the kerosene lamp; and the gas fixtures are much more convenient, as burners can be placed in each room and connected with a common supply of gas.

Coal gas and water gas. Two kinds of gas are commonly used, coal gas and water gas. Coal gas is made by heating coal in a retort so inclosed that the coal cannot burn. As a result, combustible gases are given off. These are purified and are finally stored over water in large tanks. Large pipes carry the gas to various parts of the city; and from the large pipes, small pipes lead to each house. The pressure is kept up by the weight of these tanks, which rise and fall according to the supply of gas they contain.



Section through meter **Dial**

Fig. 18. — The gas meter

Water gas is made by passing steam over heated coal. As a result, hydrogen and carbon monoxide are formed, both being gases which burn readily. Since the carbon monoxide is a very poisonous gas, great precaution should be observed in the use of water gas, to see that there are no leaks in the pipes and that the gas is not escaping at an unlighted burner.

As the gas enters the house, it first passes through a meter by means of which the amount used is measured. The pressure of the gas moves a disk back and forth, which is connected with a device that turns a hand on a dial. There are several of these dials, one measuring small amounts, about 5 cubic feet, another measuring 1,000 cubic feet, another 10,000, and another 100,000. By subtracting the reading found at any previous date from the present reading, the amount of gas used can be determined. (See figure 18.)

One way of finding out whether the gas pipes leak in the house is to make a careful reading of the meter at night after the lights are turned out and then make another reading the next day just before the gas is lighted. The difference represents the amount of gas leaked out. Even if the expense involved is slight, the leakage may be dangerous to the health of the people living in the house.

At first, burners were used at which light was given off directly by the burning gas. Later, a great improvement was made through the use of mantles, which give a stronger light and use less gas. These mantles are made of substances which do not burn, but which, when heated, give off a bright light. Mantles must be replaced occasionally, as they are very easily broken. In burners that are equipped with mantles, a special arrangement is made for admitting a large supply of air so that more complete burning takes place. This gives a higher temperature, which makes the mantles luminous.

HOME PROJECT 4

Purpose. To read the gas meter and learn the cost of the gas used.

Directions. 1. If you use gas in your home, make a reading of the meter. Make a drawing of the circles on the meter and indicate the pointer in each in the proper position. Record the reading of the meter. Notice how the gas can be turned off in case it should be necessary, as when gas escapes from a broken pipe. One week later, read the meter again and make another drawing. Subtract the first reading from the second to find how much gas was used in a week. Find the price of gas and figure out the cost of the gas used in one week.

2. In order to find out whether the gas pipes leak, read the small dial (called the test dial) just after the gas is turned off for the night. Read the dial again the next day, just before the first burner is lighted. Any difference in the readings represents the amount of gas that has leaked from the pipes.

Acetylene. The chief advantage in the use of acetylene gas lies in the fact that it can be installed in houses situated long distances from towns. The gas is made by adding water to a solid substance called calcium carbide. The apparatus is so arranged that when the water and the carbide are brought into contact the gas is collected in tanks; the amount of gas generated is regulated by pressure. The house is piped as for coal gas, and the pipes are connected with the tank. Acetylene gas gives a very brilliant white light. Occasionally one hears of dangerous explosions from the use of these outfits.

Demonstration 14

Purpose. To generate acetylene.

Apparatus. Test tube; calcium carbide.

Directions. Fill a test tube half full of water and place it on a test-tube rack. Drop into the tube a small piece of calcium carbide. Notice what happens in the water. Stand a little distance from the tube and apply a lighted match to its mouth. Note the appearance of the flame due to the burning of the acetylene.

Electricity

The latest advance made in lighting is the use of electricity, which is more convenient even than gas. More than one half of the twenty-six million homes in this country are wired for electricity.

The meter. When the current first enters the house, it passes through a meter which records the amount of electricity that is used in the house. The usual electric meter is in reality a miniature electric motor, with jeweled bearings, made with precision of workmanship to admit of ready starting and stopping with a minimum of friction. This motor runs faster or slower or not at all, depending on the amount of current used. The motor, in rotating, drives a series of gears and dial hands. A switch is usually provided so that the current may be disconnected.

Fuses. If an extra strong current should pass through the wires, they would become heated and might set fire to the house. To avoid this danger, a fuse box is provided where the current enters the house. The fuses are made of such materials that if too strong a current passes through them they melt. Thus the circuit is broken and the current does not pass through the wires in the house.

In wiring the house, care should be taken to see that the wires are properly covered with some insulator, which, being a non-conductor of electricity, will not permit the current to escape. The different lights are connected in such a way that each can be turned on and off independently of the others.

The filaments. The light in the bulb is due to the wires or filaments mounted inside, which offer so much resistance to the current that they become white hot, and their glowing produces light. In the first lamps, these filaments were usually made of carbon; now other elements, such as tungsten, are being used in place of carbon. (See figures 19 and 20.) These lamps cost more than the carbon filament lamps; but they are more economical, as they use less electricity than carbon lamps in giving the same amount of light. To prevent these filaments from uniting with oxygen and "burning up," the air is pumped out of the bulbs so that the interior of the bulb is a partial vacuum. This accounts for the loud report made when one breaks.

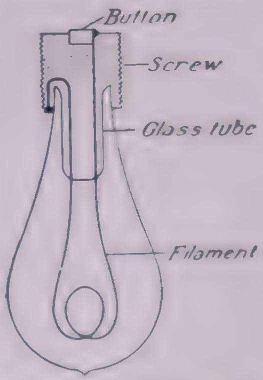


Fig. 19. — Incandescent lamp

Another type of lamp now in common use is the gas-filled lamp. Nitrogen gas, and in rare instances argon gas, is introduced after the vacuum has been formed, so as to produce an inert atmosphere. The filament metal does not oxidize in this gas, and hence it may be operated at higher temperatures, thus giving more light with less consumption of current.

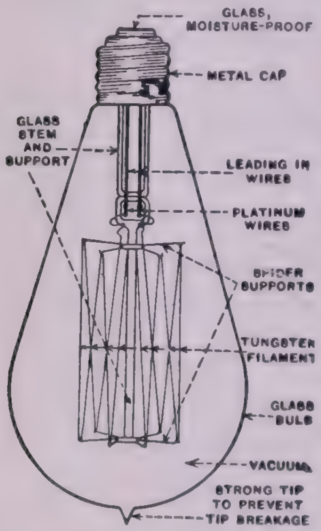


Fig. 20. — Mazda lamp

Types of lighting. Three types of lighting are in use: the direct, the indirect, and the direct-indirect. In the direct system, light passes directly from the filament in the bulb to the objects to be illuminated. In the indirect system, opaque shades beneath the lamps prevent the light from coming directly to the eye; the light passes first to the ceiling, from which it is diffused. The direct method gives brighter illumination, while the indirect is more restful to the eyes. In the direct-indirect system, some light passes through the shade and some is diffused from the ceiling.

Kinds of fixtures. The number of lights to be installed and their arrangement depend partly on the room and the use to which it is to be put. The various types of electric fixtures fall into three groups: ceiling lamps, wall lamps, and portable lamps. The main source of illumination is the ceiling lamps — the wall fixtures and the portable lamps being used more for decoration.

HOME PROJECT 5

Purpose. To read the electric meter and find the cost of electricity.

Directions. 1. If you use electricity in your home, read the meter. Make a drawing of the circles, showing the position of the pointers. Record the readings.

2. Notice how you could cut off the current if you should wish to. Can you think of any circumstances under which it might be desirable to do this?

3. One week later, read the meter again. How much electricity was used in one week? Find out the price of electricity and estimate the cost for one week.

COMPARISON OF LIGHTS

Effect on air. These different means of lighting may now be compared to see which is the best. From the standpoint of health, one detail to consider is the effect of the lighting system on the air of the room. In this respect the electric light is the best, as it does not affect the composition of the air. All other forms of lighting take oxygen from the air and give off waste products into the air as a result of burning. In those lamps in which there is a complete burning, such as the mantle gas lamp and the acetylene lamp, only carbon dioxide and water are given off. In cases where the burning is not complete, as with the kerosene lamp and ordinary gas burners, besides those compounds there are given off others which may be injurious in their effect on the health.

Effect on eyes. Another detail to consider is the effect of various lights on the eye. From this standpoint a good lighting system should meet three requirements. (1) There should be sufficient light so that the eye will not be strained. (2) The light should not produce glare by shining directly into the eye. When one reads, the light should come over the shoulder. (3) The light should be steady.

Each of the three systems — kerosene lamps, gas, and electricity — can be made to meet all three requirements if properly installed, although it is more difficult with the kerosene lamp than with the other two. The chief difficulty with the kerosene lamp is that, as ordinarily used, it does not produce enough light and gives an appearance of gloom to the home. However, for reading, a good lamp serves the purpose well if one sits in the right position. While one reads, glare may be avoided in all lamps by so sitting that the light comes from over the shoulder.

The bulbs of electric lamps should be so frosted that the filament is not visible.

GLASS AND SUNLIGHT

Houses now are brightly lighted during the daytime by the sunlight that comes through the windowpanes. But before glass was made, houses were dark and dreary, because people used oiled paper and mica in their windows. Glass today is so common and cheap that we perhaps do not realize what a great blessing it is to us. Window glass is made of pure sand and compounds of the two metals, calcium and sodium — lime and soda being the compounds commonly used. These are heated together at a very high temperature and form liquid glass. As it cools, it can be worked into various shapes. Different kinds of glass are distinguished according to the method of manufacture or the uses to which the glass is put. Plate glass is used for mirrors and windows; flint glass is used for lenses and cut glass; Bohemian glass, which is very hard and is difficult to melt, is used for chemical apparatus.

Transmission of light. It is very fortunate for us that a substance like glass has been found which permits a large amount of sunlight to enter our homes, because not only does this light enable us to see objects but, furthermore, sunlight destroys bacteria and is in other ways beneficial to health. Although sunlight comes to us from the enormous distance of 93,000,000 miles, yet so swiftly does it travel that it takes only eight minutes to pass over this distance. The speed of light is so great (186,000 miles a second) that in one second it can travel around the earth seven and a half times. It is generally believed by scientists that light is transmitted from the sun to the earth by means of waves in the ether which is supposed to fill all space. A study of the shadows cast by opaque objects shows that this light travels in straight lines.

OUTLINE SUMMARY

LIGHTING THE HOME

I. Candles
  1. The burning of a candle

II. Lamps
  1. Early types
  2. Kerosene lamps
    a. Capillarity

III. Gas
  1. Coal and water gas
  2. Acetylene

IV. Electricity
  1. The meter
  2. Fuses
  3. The filaments
  4. Types of lighting
  5. Kinds of fixtures

V. Comparison of lights
  1. Effect on air
  2. Effect on eyes

VI. Glass and sunlight
  1. Transmission of light

QUESTIONS FOR CLASS DISCUSSION

1. What advantages has the kerosene lamp over all methods of lighting used previously?

2. In what ways are the burning of a candle and of a kerosene lamp similar? In what ways are they different?

3. Of how many illustrations of capillarity can you think?

4. In what ways is gas better than kerosene for lighting?

5. In what ways is electricity better than gas?

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CHAPTER V

PROTECTING THE HOME FROM FIRE

How may fires in the home be prevented?

LOSSES CAUSED BY FIRES

Total loss. The annual loss in this country from fires is slightly more than a half billion dollars (in 1924 the figure was $548,800,000); the loss every day is a million and a half dollars; for every minute the average loss is more than a thousand dollars.

If the amount of the nation's annual loss from fires were to be invested in homes, schools, and churches, it would build a suburban city of eighty thousand homes valued at five thousand dollars each; these homes would house a population of four hundred thousand, a city the size of Cincinnati, Ohio. There would also be enough money left to build five hundred schools valued at a hundred thousand dollars each, and a thousand churches valued at fifty thousand dollars each.

Each year fifteen thousand people are killed by fires, and the number of injured is much larger. This is an average of forty people killed every day, or nearly two an hour. A cemetery large enough to bury the victims of one year would cover an area of about ten acres.

There are over five hundred thousand fires each year, averaging approximately fifteen hundred a day, or one every minute. In the time that it will take you to read this chapter, about twenty new fires will have started.

Such facts indicate the need of considering the causes of fires and the methods of protecting homes from fires.

The following table shows the number of fires and the loss for various kinds of buildings for the year 1920:

KIND OF BUILDING	AVERAGE NUMBER OF FIRES EACH DAY	NUMBER IN A YEAR	ANNUAL LOSS IN DOLLARS 1920
Dwellings	359	131,035	58,753,000
Farm buildings	96	35,040	22,788,000
Hotels	15	5,475	4,690,000
Department stores	6	2,190	9,685,000
Schools	5	1,825	6,450,000
Churches	5	1,825	3,480,000
Hospitals	1	365	1,005,000

By 1924 the average number of home fires had risen to 618 every day, or one every two and a half minutes.

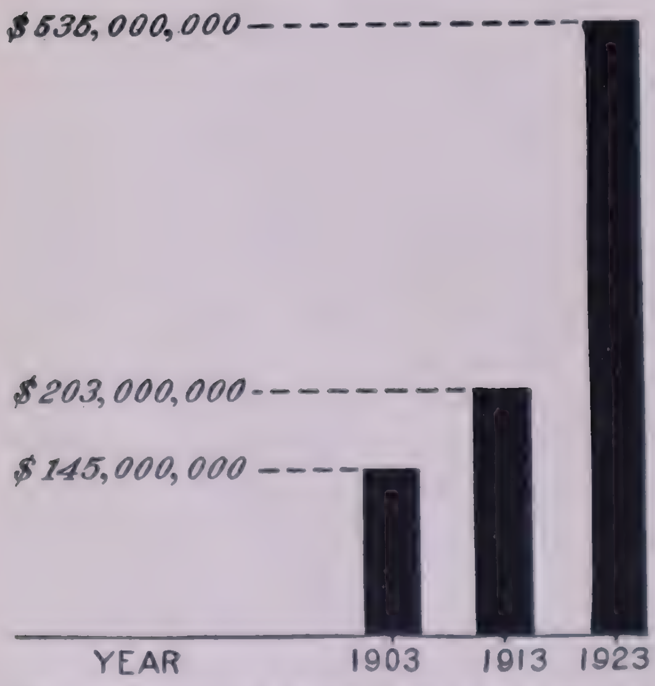

Fig. 21. — Increase in fire losses in the United States in twenty years

Increasing loss. The loss from fires is growing greater each year. Between 1912 and 1922 the population of this country increased 15 per cent, while during the same period the per capita loss increased 113 per cent, or more than seven times as fast as the population. In 1912 the per capita loss was $2.16; in 1922 it had increased to $4.61; it had more than doubled in ten years.

The contrast between the loss in the United States and that in European countries is very marked. For the year 1922 the per capita loss in Great Britain was only seventy-two cents, or about one seventh of the per capita loss in this country. In some other European countries the loss is even less than in Great Britain. One reason for this difference is the fact that fireproof material, such as stone and brick, is much more widely used in Europe. Also the laws in Europe are stricter; in some countries a man may be punished for a fire that is due to his carelessness. The people of Europe are characteristically more careful than Americans.

Loss in homes. The following table shows the loss in homes and the percentage this forms of the total fire loss:

FIRES YEARLY IN HOMES (1920)		PER CENT OF TOTAL FOR ALL FIRES
Property loss	$58,753,000	13
Number of fires	131,035	41
Lives lost (estimated)	7,500	50

The significant facts that this table shows are the large percentage of fires occurring in homes and the large number of lives lost there.

If all the houses in which fires occur in one year were to be placed on either side of one long street, allowing fifty feet frontage for each lot, the street would be 620 miles long. If a person were to walk at an average rate of three miles an hour for ten hours a day, it would take him more than twenty days to walk the entire length of this street.

If all these buildings were to be put together in one city, there would be enough buildings to house a population of six hundred thousand, which is about the size of Pittsburgh, Pennsylvania.

CAUSES OF FIRES

For all fires. Having seen the tremendous loss caused by fires, we are naturally interested to learn how these fires have started. The following table gives the causes of fires for the year 1923 arranged in order of importance:

CAUSES OF FIRES	LOSS	PER CENT OF KNOWN CAUSES
Matches — smoking	$29,045,000	11.7
Defective chimneys and flues	20,828,000	8.4
Stoves, furnaces, boilers, and their pipes	18,658,000	7.5
Spontaneous combustion	16,110,000	6.6
Sparks on roof	15,931,000	6.5
Electricity	14,091,000	5.7
Petroleum and its products	11,183,000	4.5
Lightning	10,922,000	4.4

The significant feature in this table is the fact that the causes are largely preventable. Fully three fourths of the losses from known causes were due to a combination of *carelessness* and *ignorance;* hence losses from fires *can be decreased.*

For fires in dwellings. The causes of fires in dwelling houses for the five years 1917–1921 are shown in the following table:

CAUSE	LOSS	PER CENT
Defective chimneys and flues	$31,237,000	12.2
Sparks on roofs	23,441,000	9.1
Stoves, furnaces, boilers, and their pipes	20,211,000	7.8
Electricity	16,122,000	6.3
Matches — smoking	15,824,000	6.2
Petroleum and its products	12,631,000	4.9
Hot ashes, coals, and open fires	5,808,000	2.3
Open lights	5,679,000	2.2
Lightning	5,675,000	2.2
Gas	3,475,000	1.4

DEMONSTRATION 15[1]

Purpose. To show how an explosive mixture is made.

Materials. Hydrochloric acid; zinc; wide-mouthed bottles; trough for collecting gases.

Directions. 1. Make a hydrogen generator.

2. Secure three large-mouthed bottles. Fill one full of water; a second, two-thirds full; and the third, one-third full. Invert them on the shelf of the trough.

3. Put some zinc in the large-mouthed bottle. Add some hydrochloric acid through the thistle tube. Allow the first gas to escape, as this is largely air. Put the end of the rubber tubing under the mouths of each of the three bottles and keep it there till the water is all forced out.

4. Remove each of the bottles in turn, holding a piece of wet paper over its mouth. Apply a lighted splint to the mouth of each. Which bottle gives the loudest explosion? Why?

PREVENTION OF FIRES

Care in construction of houses. Our last and most important topic for consideration is the prevention of first in the home. This topic naturally leads us to look again at the causes of fires listed on page 72. It will be noticed that the first four causes have to do largely with the construction of the house.

Great care should be used in installing the chimney, the heating system, and electricity. Chimneys should be so constructed that there are no cracks from which sparks can escape. Fire-resistant material should be used for roofing. Stoves and furnaces should be placed at such a distance from wooden material that this will not be ignited by the heat. Adjacent wooden surfaces should be protected with sheet asbestos or sheet metal; but in either case it is essential that there be an air space behind the stove. Even with this protection a separation of eighteen inches is desirable between the stove or furnace and the woodwork. The floor beneath the stove should be protected with sheet metal or a concrete base. When electric wires are installed in the home, the work should be done by an expert and in conformity with the requirements of the national electrical code so as to lessen the fire hazard.

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[1] Where conditions are such that the chemicals may be handled with safety, an experiment may be performed to show the conditions necessary for spontaneous combustion. A small piece of phosphorus is allowed to stand in some carbon bisulphide till it dissolves. A piece of blotting paper is dipped in this solution and then placed on a wire gauze on a ring stand and allowed to remain till the paper burns. Since both the carbon bisulphide and the phosphorus are easily combustible, it is advised that this experiment be performed only under conditions that permit the greatest care.

Fig. 22. — A row of gnawed roofs at Cortland, New York

From the aspect of the dwellings, it would not be hard to fancy that some flame-spitting dragon had paused to lick these house-tops.

Attention may be given to constructional features that retard fire in the home, once it starts. Fire stops in walls prevent the air spaces between the walls from acting as chimneys to supply draft to a basement fire and communicate the flames throughout the house. Metal lath and plastering act as fire preventives.

General suggestions. 1. Matches should be placed in glass, earthenware, or metal receptacles and kept out of the reach of young children. Nearly a billion matches are used every day in the United States, or nearly half a million are struck every minute on the average. Evidently great care should be taken in the keeping of matches and in the disposition of them after they are lighted.

2. Kerosene should never be poured into the fire box or grate, even when it is known that the fire is out. If it is to be used as a fire starter, the wood or paper should be soaked in kerosene *outside* the house. The kerosene can has no place *inside* a home.

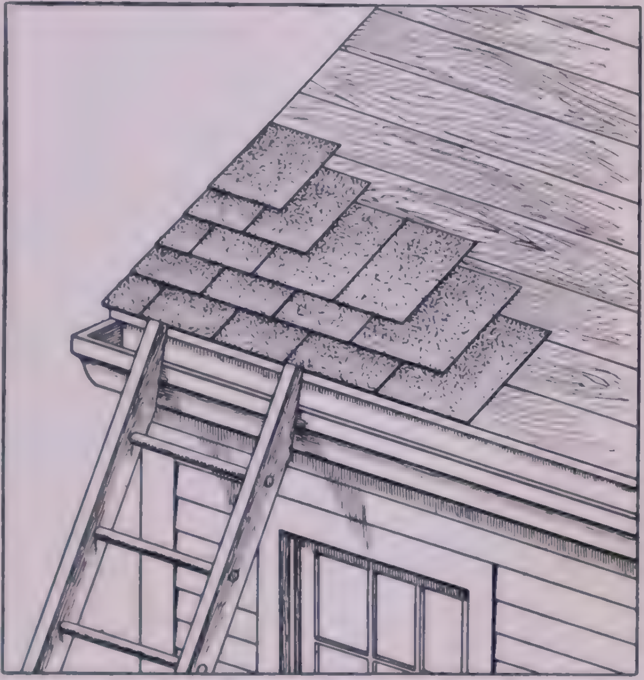

Fig. 23. — Fireproof shingles
Use of these will reduce fire loss.

3. All ashes should be put in metal receptacles.

4. Don't allow rubbish to accumulate in the cellar.

Fire extinguishers. A fire extinguisher in the home is of great assistance in putting out fires when they first start. Two types are in common use: the soda-acid type and the carbon tetrachloride type. In the first kind the tank is filled with water in which is dissolved baking soda. In a small glass bottle at the top of the tank is sulphuric acid. When the tank is inverted, the acid falls out and comes in contact with the soda in the water. As a result, large quantities of carbon dioxide gas are formed. The pressure forces the liquid out through the nozzle and throws a stream to a considerable distance. The liquid is the extinguishing element, the carbon dioxide acting only as the producer of pressure.

DEMONSTRATION 16

Purpose. To show the effect of carbon dioxide on fire.

Materials. Hydrochloric acid; chalk; tumbler; candle; outfit for generating hydrogen, without the trough.

Directions. 1. Put some chalk into the bottle and add hydrochloric acid through the thistle tube.

2. Put the end of the tubing in the bottom of a tumbler. Cover the tumbler with paper. After a minute or two insert a burning splinter into the tumbler.

3. Put a piece of candle about an inch long in the bottom of the tumbler. Light it. Place the end of the tube from the bottle in the bottom of the tumbler. Allow the carbon dioxide to form till the candle goes out.

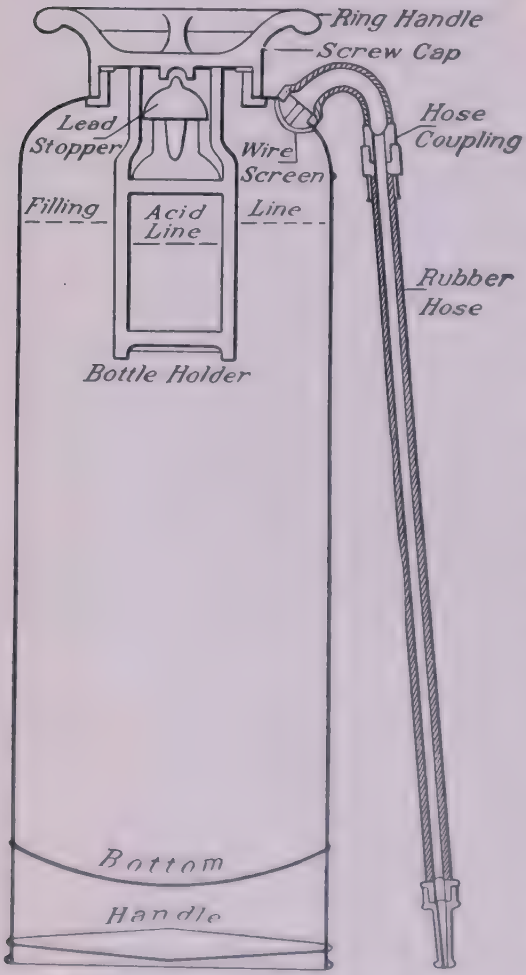

Fig. 24. — Soda and acid fire extinguisher

DEMONSTRATION 17

Purpose. To make a fire extinguisher of the soda-acid type.

Materials. Large-mouthed bottle; rubber stopper with one hole; small vial; sulphuric acid; baking soda.

Directions. (See figure 25.) 1. Through the hole in the rubber stopper insert a piece of glass tubing about four inches long. Take another piece of tubing about six inches long and hold it in a flame. When it melts, draw it out till the two pieces separate. Break off the tip of one piece, leaving a small hole. Join this tubing with the one in the bottle by means of a rubber tubing about six inches long.

2. Fill the bottle three-fourths full of water and add several teaspoonfuls of soda.

3. Secure a cork stopper to fit the vial. Cut a groove along one side. Wind a small wire around the neck of the bottle. Fill the bottle half full of sulphuric acid. Bring the wire up over the mouth of the large bottle and push in the rubber stopper so as to hold the wire in place with the vial nearly touching the rubber stopper. Push in the stopper securely and wire it to the neck of the bottle.

4. Hold the bottle over a sink and turn the bottle upside down.

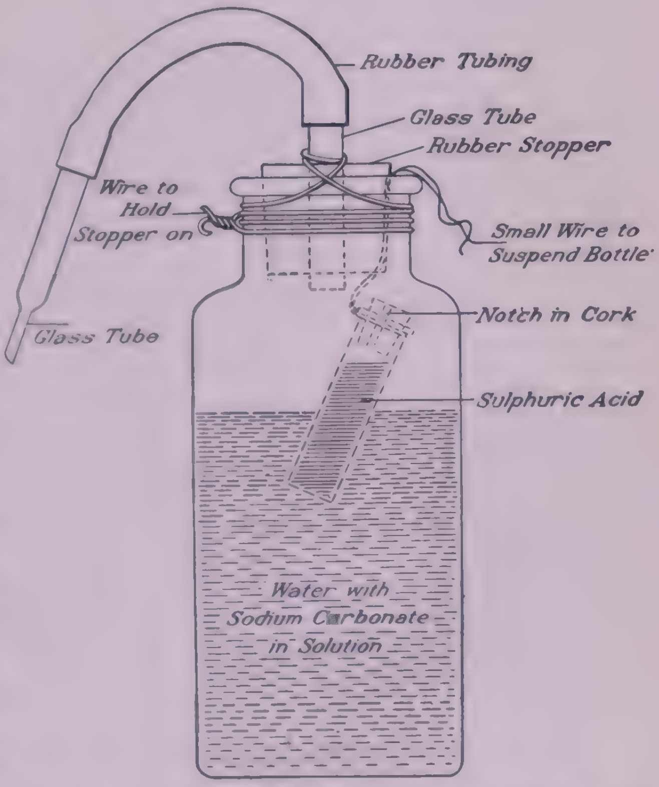

Fig. 25. — Simple fire extinguisher for laboratory demonstration

The principle of the carbon tetrachloride extinguisher is different from that of the one just described, and it works differently. It consists of a pump and is operated by moving the pump handle back and forth. The liquid carbon tetrachloride pumped out possesses properties that make it especially valuable in extinguishing fires. It boils at a low temperature, and the gas thus formed does not burn and is heavier than air. This gas forms a blanket which shuts off the air from the burning substance. This type of extinguisher is especially desirable in putting out small fires of grease, gasoline, and kerosene, where water is not effective.

This type may be kept in the garage. However, the fumes when breathed are harmful; it is not of as much value in the home as the soda-acid type. All extinguishers must be recharged after each time of using; otherwise they may not be ready when needed.

DEMONSTRATION 18

Purpose. To show how to put out burning fat.

Materials. Crisco or lard; evaporating dish; carbon tetrachloride; cloth.

Directions. 1. Put a tablespoonful of lard, or crisco, in an evaporating dish and heat till it takes fire. Add a little water.

2. Heat the fat again and cover with a piece of wet cloth.

3. Heat the fat again till it burns. Add some carbon tetrachloride.

Automatic sprinklers. These sprinklers contain a "head" made with an alloy that melts at a low temperature. In case of a fire the alloy melts, and thus the water, which is kept under pressure, is forced out. These are specially adapted for use in schools, hospitals, factories, stores, and apartment houses. When properly installed these are very effective in putting out a fire in its early stages.

Work of governments to control fires. In order to lessen the chance of fires, the larger cities have ordinances regulating the construction of buildings. Among these are regulations compelling the use of certain fireproof materials within specified crowded parts of the cities, and laws regarding the inspection of electric wiring. Some states also regulate the construction of schoolhouses to reduce the fire hazard.

City fire departments. Our larger cities now have efficient departments for fighting fires and for saving lives. In the old days we had the machine with pumps worked by hand, drawn by horses, and manned by volunteers; today we have machines with pumps worked by engines, drawn on auto-trucks, and manned chiefly by trained and paid firemen.

The alarm system. The fire station may be notified of fires in several ways: by a system of fire-alarm boxes, by telephone, and by connection with an automatic sprinkling system. The alarm system is so constructed that when an alarm is sent in from a box, a gong sounds at a neighboring station, and the number of the box is shown on the indicator. The use of the automobile trucks enables the firemen to reach the scene of a fire quickly.

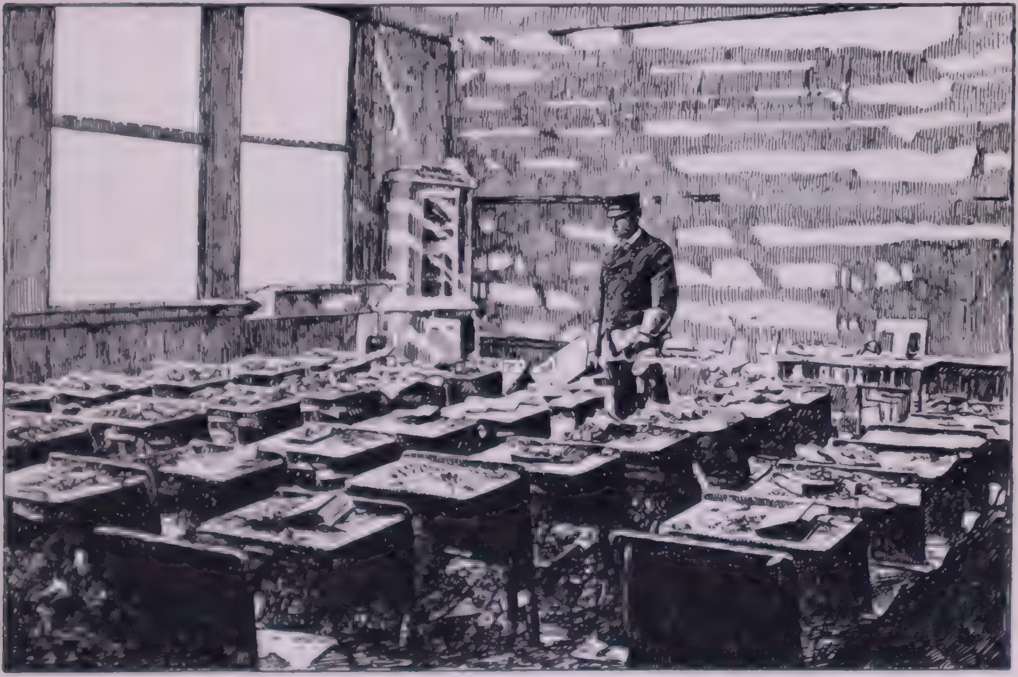

Fig. 26. — Again the fire drill proves its worth

Fire Marshal Edward Grenfell of Portland, Oregon, inspecting the ruins of the Halladay School, destroyed by fire. Five hundred pupils were marched out in less than a minute after the sounding of the alarm.

Types of trucks. Several types of trucks are kept in the station houses — the chemical truck, the engine truck, the hose truck, and the ladder truck. The most important feature in fighting a fire is to attack it as early as possible. For this purpose the chemical truck is often used. A great many fires are extinguished by this apparatus alone. It is a very large fire extinguisher of the soda-acid type mounted on a truck. The principle of operation is the same as explained on page 75. This truck is provided also with other kinds of fire extinguishers and with fire tools.

The purpose of the engine truck is to make use of the city water supply. It contains a powerful force pump driven by the same engine that runs the truck. It also carries hose for connecting with hydrants. Various types of nozzles are carried, to be used according to the conditions existing at the fire. One type, called the cellar nozzle, is used for fighting cellar fires. A hole is knocked in the floor and the nozzle is dropped through this hole. Another truck, known as the hose truck, carries a large amount of hose for use in case the hose on the engine truck is insufficient.

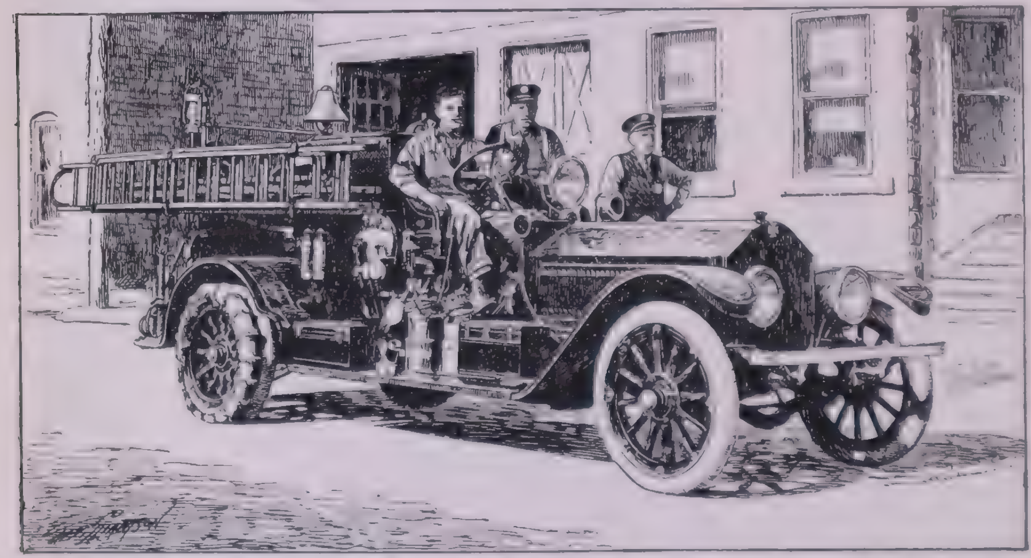

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Fig. 27. — Engine for fighting fires

The ladder truck carries both stationary and portable ladders. The stationary ladder, which is lifted by machinery, may range in length from fifty to ninety feet. This truck carries many accessories, such as scaling ladders, smoke masks, and various kinds of fire-fighting tools.

The usual department is equipped not only with devices for fighting fires but also with devices for saving lives. Among these are life nets (into which people trapped in a burning building may jump), life lines, stretchers, and emergency outfits.

FIELD EXERCISE 1

Purpose. To visit a city fire department.

Directions. If the teacher will speak beforehand with the chief of the fire department, arrangements can probably be made for the class to visit the building and have someone show the fire apparatus and explain its use. If the class is too large to be taken on such a trip, a small section may take the trip and later make a report to the class.

Principles involved in fire control. Three conditions are necessary for starting a fire: (1) air, (2) a substance that will unite with the oxygen of the air, and (3) a proper temperature at which these two will unite, known as the kindling temperature. If any one of these conditions is lacking in the first place, the fire cannot start. If any one is removed after the fire starts, it cannot continue burning. In the various means used to prevent or stop fires, efforts have been made to remove each one of the three.

First, and of great importance in preventing fires, is the removal of the second condition by the substitution of fireproof material (such as brick, concrete, stone, and metal) for combustible material (such as wood).

Fires may be put out by smothering them — that is, by shutting off the supply of air — or by cooling them. Water acts in two ways in putting out a fire: It lowers the temperature, and the water and the steam formed from it act as a blanket which excludes the air. One effective way of putting out burning fat in the kitchen is to smother it by means of a cover. The carbon tetrachloride used in one type of extinguishers cuts off the supply of air.

OUTLINE SUMMARY

Protecting the Home from Fire

I. Losses caused by fires
  1. Total loss
  2. Increasing loss
  3. Loss in homes

II. Causes of fires
  1. For all fires
  2. For fires in dwellings

III. Prevention of fires
  1. Care in construction of houses
  2. General suggestions
  3. Fire extinguishers
  4. Automatic sprinklers
  5. Work of governments
  6. City fire departments
    a. The alarm system
    b. Types of trucks
  7. Principles involved in fire control

QUESTIONS FOR CLASS DISCUSSION

1. To what extent can fires be prevented?

2. Which is a greater fire hazard in the home, the heating equipment or the lighting equipment?

3. In building the house what precautions may be taken to lessen the danger from fire?

4. How do the two fire extinguishers differ?

5. What may be done to a fire to put it out?

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CHAPTER VI

THE HOME WATER SUPPLY

1. What care should be taken to see that wells and other sources of drinking water are kept pure?

2. What has the air to do with the working of a pump?

3. Which is the best method of getting running water in the home?

Types of Water Supplies

The various kinds of supplies from which the farm home may get its water may be grouped into two classes: underground water supplies and surface water supplies. To the first group belong wells and springs; to the second group, cisterns, streams, and lakes.

Dug well. Wells are of four kinds: dug, bored, drilled, and driven. The dug well is probably the oldest type of well known. It consists of a hole dug in the ground down to the water level. This well is usually provided with a casing and a cover.

Bored well. This is similar to the dug well, only with a much smaller diameter. The bored well is usually made by means of augers. This type is usually cased with some such material as wood, tile, concrete, or iron pipe.

Driven well. To make a driven well, a pipe with a hard point is driven into the ground till a layer of earth is reached that has a constant supply of water. The pipe is removed and the driving point is replaced with a filtering point covered with a sieve, which allows the water to enter but prevents the dirt from filling the pipe. The pipe is then driven down again. This kind of well is usually found in locations in which water is reached near the surface and in which the earth formations are comparatively soft. Some of the objections to this type of well are the limited amount of water that can be pumped at one time and the possibility that the pipe may become clogged with dirt.

Drilled well. By means of drilling apparatus a hole is drilled in the ground, and a pipe is driven down the hole as fast as it is drilled. This well is found most often in sections in which water is reached only at considerable depth and in sections in which solid rock is encountered. The casing is composed of steel or wrought iron pipe, which in some wells extends throughout the entire length, while in others it extends only to the water-bearing rocks. This casing may be brought up to the surface and attached to the bottom of a well-pit, which may be from eight to twelve feet deep and three to four feet square. However, it is better after the drilling is finished to fill in the pit with compact earth.

A satisfactory water supply for drinking purposes should meet three conditions: First and most important, it should be free from bacteria that might cause disease; second, it should be free from disagreeable odor; and third, it should be pleasant to the sight and the taste. In the discussion that follows, we are interested chiefly in the first condition.

HOW WATER MAY BECOME IMPURE

The diseases most likely to be carried by water are typhoid fever and dysentery. The bacteria of these diseases leave the body chiefly in the discharges from the bowel and the bladder. These bacteria may enter drinking water in several ways: (1) The discharges may be dumped directly into the water; (2) they may be placed on the ground and then later may be washed or carried into the water supply; (3) water after it is drawn may be polluted by contact with hands which have been contaminated with disease germs.

Underground pollution through the soil is now believed to be a very rare happening. Surface pollution is far more frequent. When the slope of the ground is toward the well, impurities on the surface may easily be washed into the well. All open wells from which the water is dipped in buckets are very unsanitary. "The old oaken bucket" may continue to exist in our minds as a romantic memory, but as a means of securing drinking water it should be condemned. Priming a pump is unsanitary, since it may be a means of introducing impure water into the well.

HOW TO HAVE A SAFE WATER SUPPLY

In order to prevent disease germs from entering wells, attention should be given to three important matters: the location of the well, its construction, and its operation.

Location of well. In locating a well the following matters should be taken into account: (1) It should be located as far as possible from such sources of pollution as cesspools and sewers; (2) the surface should slope *away* from the well; (3) it should be above the point at which surface flooding from streams might occur.

Construction of well. The main thing to consider in the construction of the well is how to prevent the entrance of *surface* water into the well. As surface water passes down through the soil, it is purified by removal of the disease-producing bacteria. Under ordinary conditions the depth of compact soil needed to bring about this purification is about ten feet.

In the construction of a dug well, three important conditions should be met: (1) The casing should be water-tight for a depth of at least five feet below the surface, the distance depending on the soil; (2) the casing should also extend high enough above the surface level to make a grade which will permit drainage *away* from the well; (3) the covering should be water-tight. Concrete is one of the most satisfactory materials to use for the casing and the cover. Wood should not be used for the construction of the cover, since it cannot easily be kept water-tight.

Operation and care of well. Water should never be drawn from the well by means of buckets. Some type of pump should be installed in such a way that priming is not necessary. The most sanitary type of pump has a pump head in which the opening through which the pump rod passes is protected by a high collar and a long cap overlapping the collar. The cover and the casing should be watched to see that no cracks develop through which surface water may find entrance to the well.

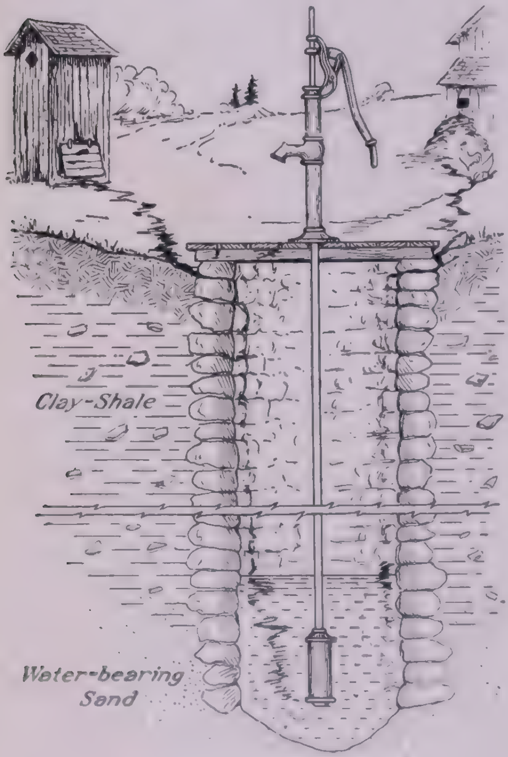
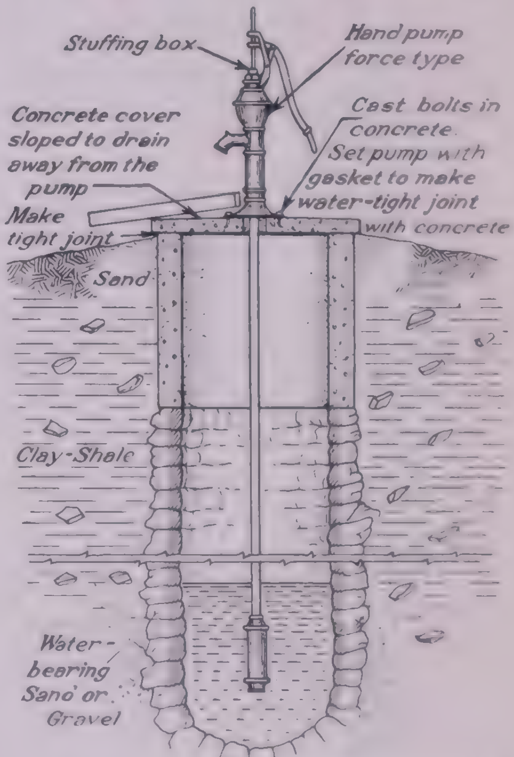


Fig. 28. — How pollution may enter a poorly located and constructed dug well


Stuffing box
Hand pump force type
Concrete cover sloped to drain away from the pump
Cast bolts in concrete
Set pump with gasket to make water-tight joint with concrete
Make tight joint
Sand
Clay-Shale
Water-bearing Sand or Gravel

Courtesy of Minnesota State Board of Health

Fig. 29. — How a dug well can be protected against pollution

Special reference has been made to the dug well in the discussion of the protection of the water supply. The same general principles apply to other types of water supplies. The difference lies merely in the details by which these principles are applied.

PUMPS

Cistern pump. After the purity of the water is assured, the next question to consider is the method by which the water is brought into the house and distributed. One of the most common methods, especially for cisterns, is the pump. The ordinary cistern pump, or suction pump (see figure 30), consists of a cylinder *C* with a piston *P* that works inside the cylinder. This piston has a leather washer which fits the cylinder tightly. In the center of the piston is a weight or valve *V* so arranged that pressure from above closes it tight, while pressure from below opens it. At the top of the pipe *T*, where the pump is fastened, is a similar valve *S* which opens up and lets the water through, but which closes down and prevents the water from going back. A pipe *T* connects the cylinder with the well or cistern.

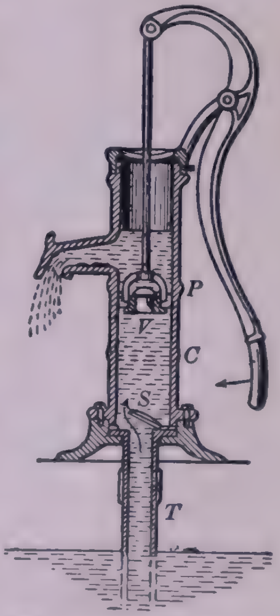


Fig. 30. — A suction pump

How the pump works. In order to understand how the pump works, let us suppose that the cylinder is full of water and that the piston is up. When the piston moves down, the valve *V* in the piston opens and the water passes through. When the piston moves up, the valve *V* in the piston closes and the water above is lifted and flows out through the spout. At the same time the lower valve *S* is opened upwards and the water enters and fills the cylinder; and then the operation is repeated as before.

It is easy to understand how the piston and its valve work, but what causes the lower valve to open and the water to rise? To push water up in this way requires some force, and we are curious to know what this force is. It is the weight of the air pressing down on the surface of the well that forces the water up the pipe.

Weight of air. Perhaps you do not realize that the air has weight, but this fact has been proved by experiment. The air has been pumped out of air-tight vessels by means of an air pump, and the vessels have been weighed before and after removing the air. The second weight is found to be less than the first, the difference being the weight of the air. While air is very light, it extends up so high — perhaps a hundred miles or more — that the total weight of air bearing down on any surface is very great.

Experiments have shown that the air bearing down on each square inch of surface weighs fifteen pounds, so that the air bearing down on your hand weighs about three hundred pounds. How, then, can you hold your arm out straight with all this weight on it? You are able to do this because the air that touches the under side of your hand pushes up with the same force as that with which the air on the upper side of your hand pushes down, so that the two pressures balance and you do not feel the weight. Likewise the air exerts an equal pressure sidewise, thus keeping its weight balanced in every direction. It is only when the air is removed from a space by means of some machine, such as an air pump, that the unbalanced pressure shows its tremendous force.

The weight of air presses down on the water in the cistern and the pressure is exerted all through the water, so that, at the opening of the pipe, water is forced up the pipe and into the cylinder of the pump. When the piston of the pump is raised, a vacuum is formed in the cylinder and, to fill this space, water is forced up by the weight of the air on the surface of the water in the cistern.

As there is a limit to the weight of air, so there is a limit to the height to which water may be pumped by the common suction pump. This limit is the height of a column of water which is one inch square and weighs fifteen pounds. This height is found to be about thirty-two feet. Air will not force water higher than this, because the weight of this height of water is just balanced by the weight of air extending up as high as the air goes.

DEMONSTRATION 19

Purpose. To show that air has weight.

Apparatus. Air pump; bell jar with open top; rubber membrane.

Directions. Tie a piece of rubber sheeting over the open top of a bell jar. Place the bell jar on the stand of an air pump and remove the air by means of the pump.

DEMONSTRATION 20

Purpose. To show that air has weight and hence exerts pressure.

Apparatus. Test tube; glass tubing about six inches long; glass tumbler; piece of paper; rubber tubing about a foot and a half long; pint milk bottle; hard-boiled egg with shell removed.

Directions. 1. Fill a test tube with water. Place your thumb over the end and invert the tube in a dish of water. Remove your thumb after the end of the tube is under water. Why does the water stay in the tube?

2. Put a piece of glass tubing in water till it is entirely covered. Place your finger over the upper end and remove the tube from the water. Why does the water remain in the tube? Remove your finger. Why does the water fall?

3. Fill a tumbler with water. Over the top place a piece of paper and press it down firmly on the rim. Hold the paper on with one hand and invert the tumbler with the other. Remove the hand from the paper. What keeps the paper up?

4. Place a piece of rubber tubing about a foot and a half long in a dish of water. When the tube is full of water, pinch one end of the tube with the thumb and finger and bring it out over the edge of the dish into another empty dish placed a little lower than the first. Remove the hand. What makes the water flow? Raise the second dish higher than the first keeping the end of the tube under water, and note what happens. A tube used in this way is called a siphon.

5. Light a piece of paper and drop it into a pint milk bottle. After the flame goes out, put a hard-boiled egg with the shell removed in the mouth of the bottle. How do you explain what happens?

6. Do these experiments help you to explain the working of a fountain pen filler and why it is possible to drink soda water by means of a straw?

DEMONSTRATION 21

Purpose. To show how a pump works.

Apparatus. A small cistern pump or a glass model of a lift pump.

Directions. Operate the pump and note carefully how it works. Take it apart and examine the various parts. Make a drawing of the pump and explain how each part works.

Lift pump. The ordinary suction pump can be used only for shallow wells not exceeding a depth of thirty feet. For wells deeper than this, a modified form of the suction pump is used. Both valves are in a movable cylinder, which is placed in a large pipe within thirty feet of the surface of the water. The pressure of the air forces the water up to the cylinder, and from here it is lifted by means of a rod attached to the cylinder at one end and to the pump handle at the other. Frequently the cylinder is kept below the surface of the water in the well.

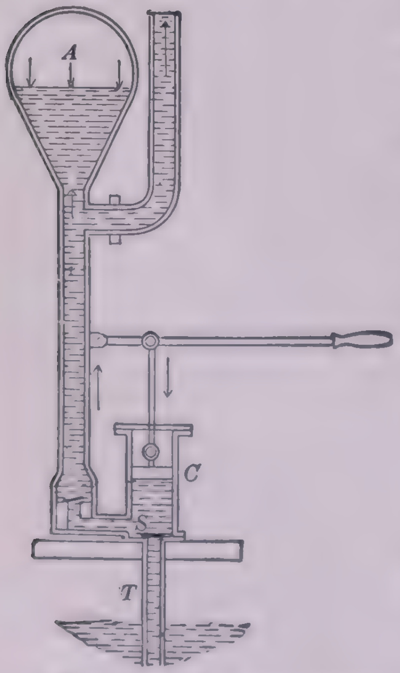


Fig. 31. — A force pump

Force pump. If water is to be forced higher than the spout of the pump, a force pump is used (see figure 31). The lower part *ST* is like that of the ordinary pump. The spout, instead of being open, is a water-tight pipe which connects with an air dome *A*. As the pump is worked, water is forced into this dome and compresses the air there, which in turn forces the water out through another pipe, thus giving a steady flow of water.

RUNNING WATER IN THE HOUSE

It is easier and less expensive than is commonly thought to have running water in the house; and the convenience is worth the expense many times over.

Gravity system. Under certain conditions the gravity system may be used. For this purpose the stream or spring must be high enough above the house so that the water may be piped directly from the source of water supply into the house. While this system is cheap and reliable, the necessary conditions are found only occasionally.

Hydraulic ram. When the source of water is below the level of the house, some kind of pump and power to work it must be used. The cheapest method is the hydraulic ram, which requires a running brook with sufficient fall to furnish the needed power, and with a very liberal supply of water, as the machine wastes about seven times as much water as it pumps. The principle involved is that some of the energy of the running water is used to compress air, and this compressed air forces water through the pipes. The ram may pump the water from the brook that operates it, or it may pump water from a separate source. The advantages are that it is very cheap to operate and that it requires no one to attend to it. Its disadvantages are that there may not be enough fall of water or stream flow to operate it, and that the accumulation of air in the summer and the formation of ice in the winter may interfere with its operation.

Windmill. Another cheap source of power is the windmill. The wheel of the windmill is made of strong blades of wood or steel, curved or flat, and set at such an angle that the wind blowing against them causes the wheel to turn. The wheel must be kept at right angles to the wind in order to be turned by it, and the wheel is kept in this position by a fanlike tail. When it is desired to stop the wheel, this tail can be turned by means of a wire so that it is parallel with the wheel, which then turns its edges toward the wind and ceases to rotate. On the axle is a cogwheel that fits into another cogwheel to which is fastened a crank. This moves the piston of the pump at the base of the windmill up and down. A serious objection to the windmill is that the time of its operation cannot be controlled. There may be long periods of calm, and a large tank must be provided to allow for this possibility. Water may be piped directly from the elevated tank to the house.

In the northern states an objection to the outdoor tanks, by whatever method filled, is the danger of freezing during the severest weather. Tanks are sometimes placed in the attic of the house, but there is always the danger of leakage or that the weight of the tank when full may prove too great a strain for the house.

Pressure tank. On the whole, one of the most satisfactory devices is the pressure or pneumatic tank (see figure 32). This is an iron cylinder, which may be located in the cellar or sunk in the ground below frost line. This is connected with the well, and by means of a pump the water is forced into the tank. At the same time the pump compresses the air above the water in the tank, and this compressed air forces the water from the tank up through the pipes leading to

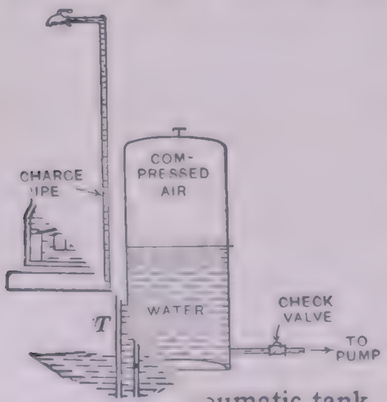


Fig. 31. — A umatic tank

of the house. Arrangements are made to an air dome *A*. A the tank to take the place of the air dissolved this dome and comp pumping may be done by hand, by wind-

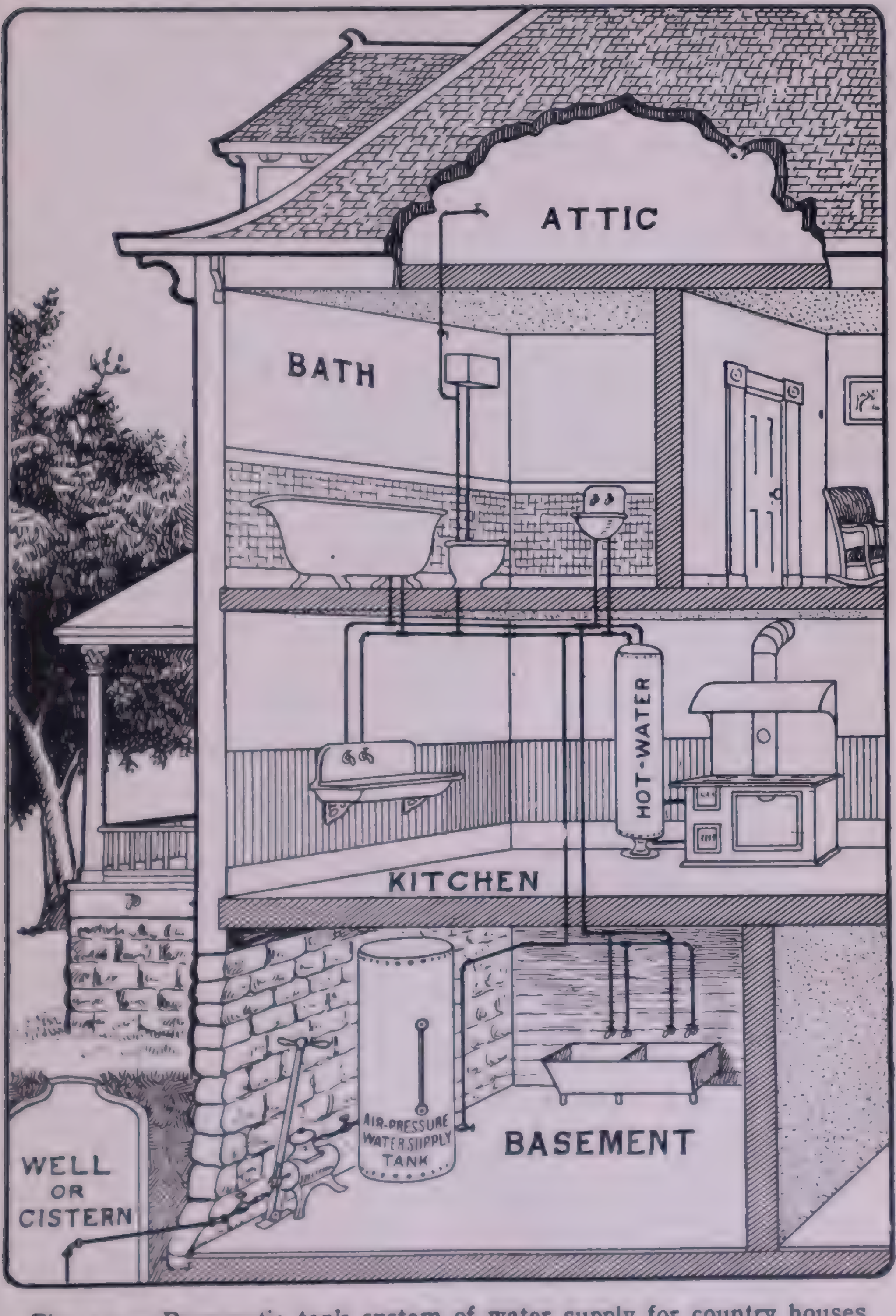


Fig. 33. — Pneumatic tank system of water supply for countrv houses

mills, by gasoline engines, or by electric motors. Where electricity is available, the electric motor is the most convenient, as it may be arranged to work automatically according to the air pressure, both to start and to stop.

DEMONSTRATION 22

Purpose. To construct a simple pressure tank.

Apparatus. Large-mouthed bottle; force pump; rubber tubing; glass tubing; rubber stopper with two holes; ring stand.

Directions. 1. Bend a long piece of glass tubing into a U-shape with one short arm. Insert this short arm through one hole in the rubber stopper. Through the other hole put a short, straight piece of glass tubing.

2. Put the stopper in the bottle, invert the bottle, and support it on a ring stand. Wire in the stopper securely.

3. Connect the short piece of glass tubing with the outlet of a force pump by means of a rubber tube. Connect the inlet opening of the pump with water.

4. Work the pump and notice what happens.

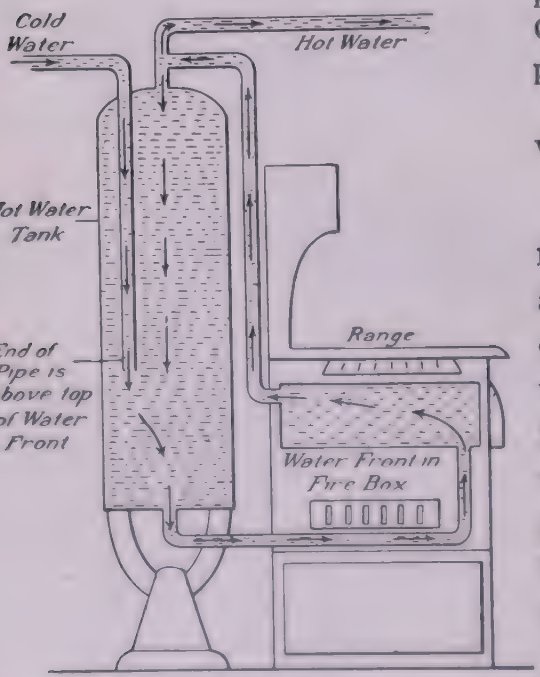


Fig. 34. — Hot-water tank and water front in range

Hot-water tank. Running water in the house allows of a constant supply of hot water during the cold weather. The cold water is first brought into the hot-water tank by means of a pipe extending nearly to the bottom of the tank. The water is heated by passing through coils of pipes that are placed in the stove or furnace. From here it passes back to the tank, where it accumulates in the upper half, from which it is drawn off and circulated through the house.

OUTLINE SUMMARY

THE HOME WATER SUPPLY

I. Types of water supplies
    1. Dug well
    2. Bored well
    3. Driven well
    4. Drilled well

II. How water may become impure

III. How to have a safe water supply
    1. Location of well
    2. Construction of well
    3. Operation and care of well

IV. Pumps
    1. Cistern pump
        a. How the pump works
        b. Weight of air
    2. Lift pump
    3. Force pump

V. Running water in the home
    1. Gravity system
    2. Hydraulic ram
    3. Windmill
    4. Pressure tank
    5. Hot-water tank

QUESTIONS FOR CLASS DISCUSSION

1. Which is the best type of well?

2. How do the lift pump and the force pump differ from the cistern pump?

3. What are the advantages of having running water in the house?

4. Of how many facts can you think which show that air has weight?

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CHAPTER VII

THE HYGIENE OF THE DINING ROOM

How may we know the kind and the quantity of the food we should eat in order to keep our bodies in the best of health?

In considering the hygiene of foods, three questions naturally arise: First, *what* we shall eat; second, *how much* we shall eat; and third, *how* we shall eat.

THE SELECTION OF FOODS

Uses of foods. In order to answer the first question, as to *what* we should eat, we must first understand the uses to which foods are put in the body. Foods serve three purposes: First, they furnish material for the growth and repair of the tissues of the body; second, they supply the body with fuel, which yields heat to keep the body warm and furnishes power by which the muscles work; and third, they regulate some of the functions of the body, as the beating of the heart, the digestion of the food, and certain changes which are constantly taking place in the tissue cells. Those foods that supply the first of these purposes may be called *growth* foods; those that supply the second, *fuel* foods; and those that supply the third, *stimulation* foods.

These are the three primary considerations that everyone needs to take into account in the selection of foods. In addition, some people need to consider two other factors in choosing foods: their effect in preventing constipation, and their effect in reducing weight.

Classification of foods according to composition. Studies of foodstuffs show that while we have a great variety of articles of dietary, the nutrients contained in them, which actually nourish the body, may be classified in a very few groups. The five classes of nutrients are proteins, fats, carbohydrates, water, and mineral matters. All of our foods contain one or more of these nutrients. Examples of protein are found in both the yolk and the white of eggs, in the lean part of meats, and in the gluten of flour; examples of carbohydrates are starches and sugars; examples of fats are butter and the fatty portions of meats.

DEMONSTRATION 23

Purpose. To test foods for different kinds of nutrients.

Materials. Various kinds of foods; iodine; nitric acid; ammonia.

Directions. 1. To test for starch. Heat a little cornstarch in water and allow it to cool. Then add a few drops of dilute solution of iodine in alcohol. A blue color shows the presence of starch. In a similar way test a number of common foods.

2. To test for proteins. Add a little nitric acid to a piece of meat in a test tube and boil. Pour out the acid, rinse the meat in water, and add ammonia. The yellow color is a test for proteins. Test a number of foods for proteins.

3. To test for fats. Place a piece of butter on a sheet of writing paper and warm over a flame till it melts. Then rub off the butter and notice the change that has taken place in the paper. Making the paper transparent is a test for fat. Test other foods for fat.

4. Put records in the form of the following table:

KIND OF FOOD	STARCH	PROTEIN	FAT

Put the names of the foods in the first column and put a check opposite each food in the proper column to correspond with the tests.

Uses of nutrients. The only kind of nutrient that can build tissue is protein; hence a certain amount of this kind of food is absolutely necessary for the structural maintenance of the body. While proteins may also serve as fuel in the body, it is better that most of this fuel be obtained from other and simpler foods. Carbohydrates and fats cannot build tissues; they serve the purpose of foods in yielding fuel to keep the body warm and to furnish energy for the muscles. Mineral matters aid in forming bone and other tissues and help to regulate some of the activities of the body. Water supplies the body tissues with fluid and carries nutrients in solution. It is also an agent of circulation and of elimination.

Vitamines. Recent studies of foods have shown that, in addition to the five nutrients mentioned above, there are other substances, called vitamines, that are necessary to a proper dietary. These substances serve a very vital purpose in regulating some essential body processes, such as the absorption of food from the intestines. When these vitamines are lacking in the dietary, serious results to health follow. It is known that there are several classes of these substances. One, called Water Soluble B, is found in many foods, including milk, eggs, meat, the bran and germ of cereals, juicy vegetables, peas, beans, and probably all fruits. Another, called Fat Soluble A, is found less widely distributed, and more care is necessary in planning the diet to see that it is included. This is found in green leaves — such as lettuce — in eggs, liver, and the fat of milk. It is found to a lesser extent in meats generally, and especially in the organs of the body and the fat near them.

Protein is the most important constituent of growth foods; fats and carbohydrates are the most important constituents of fuel foods; vitamines and mineral matters, of stimulation foods; indigestible fibers, of constipation-preventing foods; and lack of fuel value characterizes reducing foods.

Sources of proteins. Protein is an important part of meats, fish, beans, peas, cereals, and nuts. It comprises about one tenth of cereals, one seventh of meats, one fifth of dried beans and peas, and one fourth of cheese. Nuts vary greatly in composition, peanuts containing about one twelfth protein. Fruits and vegetables contain only small quantities of protein.

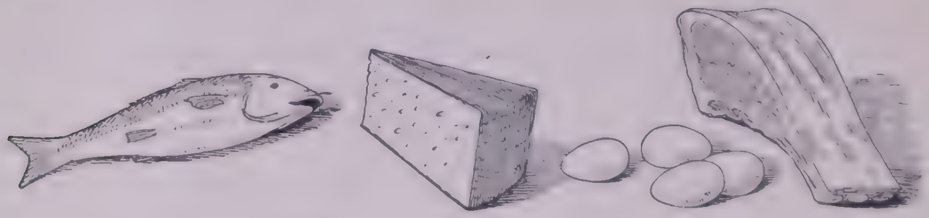

Fig. 35. — Protein foods

Sources of fats and carbohydrates. The chief sources of fats are nuts and the animal foods. The carbohydrates are obtained almost entirely from vegetable foods, milk and liver being the only animal foods that contain any considerable quantity. The carbohydrates make up about two thirds of peas and beans, three fourths of the cereals, and a large proportion of the nutrients of vegetables and fruits. It is thus seen that animal foods contain large proportions of protein and fat with small proportions of carbohydrates; while vegetable foods contain large proportions of carbohydrates and but little fat, and some contain large proportions of protein.

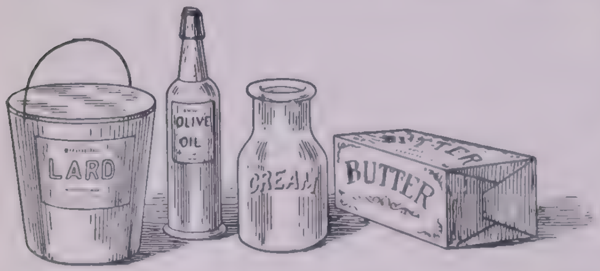

Fig. 36. — Fat foods

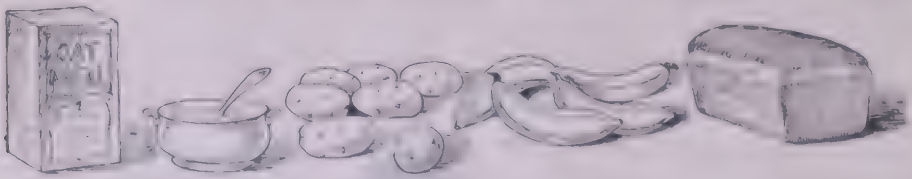

Fig. 37. — Carbohydrate foods

Water. Water forms a large proportion of nearly all foods, the amount varying greatly. Vegetables and fruits contain the largest proportion, ranging from 80 to 95 per cent. Nuts and dried foods, like peas, beans, wheat, and corn, contain the smallest proportion, ranging from 5 to 15 per cent. Meats contain a medium amount, ranging from 50 to 70 per cent.

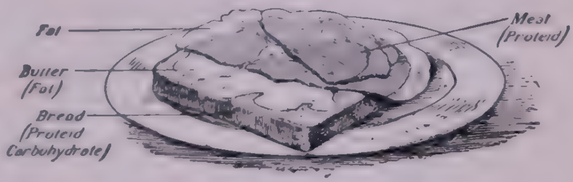

Fig. 38. — Food elements in a sandwich

Classification of foods according to source. In relation to their source, foods may be divided into two large groups: animal and vegetable.

Animal foods. The more common animal foods are milk (and its products), eggs, meats, and fish. These foods are our best sources of proteins, and they give an appetizing flavor to other foods. While meats may well form a part of every dietary, they should not be eaten to excess; and, as a general thing, they should not be eaten oftener than once a day. Many people eat too much meat for their best health. The average yearly consumption of meat and fish for every person in the United States is half a pound daily. Most people would undoubtedly be better off if they ate less than this.

Milk is one of our best and cheapest foods. It is not merely a drink but a food that is easily digested and very nourishing. It is well balanced in the proportions of nutrients that it contains, as shown in the table on page 102. Milk serves all the three purposes of foods. It furnishes energy at a moderate cost in comparison with other foods; it is a cheap form of protein; and it contains an abundance and a variety of the vitamines which are so essential in regulating the body activities. It is the richest of all the common foods in lime — a substance necessary to build bones, cartilage, etc.

Milk is necessary for growing children, as it contains the elements that promote their proper growth and development. Children should have at least a quart of milk or its equivalent in milk products daily. Adults may use milk in their diet to replace many of the more expensive foods. The use of milk is one of the best ways to reduce table expenses. A glass of milk is about equal in food value to any one of the following: two eggs, two slices of bread, two potatoes, or a large serving of meat. One can get the same kind of nourishment from milk as from a meal made up of fats, meat or eggs, sugar, and cereals, combined with salt and water.

	WATER	PROTEIN	FAT	CARBOHYDRATES
Whole milk, per cent . .	87	3.3	4	5
Skimmed milk, per cent .	90.5	3.4	0.3	5.1

Milk may become unfit for food, especially for babies, by improper treatment in the home. This bad treatment usually consists of placing it in unclean utensils, exposing it unnecessarily to dust, flies, etc., or failing to keep it cold. As soon as the milk is delivered to the home, it should be placed in the refrigerator and allowed to remain there until used. Milk cannot be properly kept without ice except in cold weather. Unless the milk bottle is in actual contact with the ice, the milk will be kept cooler in the bottom of the refrigerator than in the ice compartment.

Milk should be kept in the original bottle and not poured into a pail or pitcher for storage. The milk bottle, especially its mouth, should be carefully wiped with a clean towel or rinsed before the milk is poured from the bottle, so that dust or dirt that may have gathered on the cap will not get into the milk. Milk should not be poured back into the bottle after it has been exposed in other vessels.

The milk bottle should be kept covered with the paper cap; or, if the cap has been punctured, the bottle may be covered with an inverted tumbler. Milk should not be left standing uncovered in a refrigerator containing food of any kind, as it absorbs the odors very quickly and becomes unfit for food.

As soon as a milk bottle is empty, it should be rinsed in warm water until it appears clean and then inverted to drain. There is no necessity for washing and scalding the milk bottles, because the dealer will wash and sterilize them when they reach the plant. Rinsing the bottles immediately after they are emptied prevents the accumulation of material in them that would be difficult to remove when they are washed at the plant. Milk bottles should not be used for any other purpose than holding milk.

Vegetable foods. The vegetable foods are commonly divided into the following groups: green vegetables, such as lettuce and corn; tubers and roots, such as beets; legumes, such as beans; fruits, such as apples; cereals, such as wheat; and nuts.

While fruits and green vegetables do not contain large proportions of solid nutrients, yet they are among the best foods and should occupy a prominent place in every dietary. They are composed largely of water; of the nutrients present, carbohydrates are the most common. These carbohydrates help to furnish a well balanced diet when used in connection with the protein foods. In addition to their direct food value, they serve other important uses. The pleasant flavors of fruits and vegetables serve to make other foods more palatable and so aid in their digestion. They furnish some of the mineral salts needed by the body and, by the bulk of material which they contain, they assist in the efficient working of the digestive organs. Fruits and vegetables are valuable also because they contain vitamines.

Vegetables and some fruits can be easily raised in the home garden at slight expense and with but little labor. Vegetables can be raised from seed in one season. The fruits, excepting fall strawberries, require longer to mature, varying from two to eight years. Vegetables have good keeping qualities, and of the surplus raised in the summer many kinds may be stored or canned for winter use.

The advantage of a mixed dietary. In the selection of food to furnish the protein that we must have, we may choose from meats, fish, eggs, milk, beans, peas, cereals, and nuts. The carbohydrates come almost entirely from vegetable foods; the fats largely from animal foods and, to a minor extent, from nuts. Thus it will be seen that it is possible to obtain all the nutrients the body needs from vegetable foods alone. There are some people, called vegetarians, who maintain that a dietary composed of vegetable foods alone is more healthful than one composed of both animal and vegetable foods; but common experience and medical authorities agree that for most people a mixed dietary is preferable to one solely vegetarian.

From the standpoint of the origin of foods, we may say that our best growth foods come from animal sources; our best fuel foods are chiefly of vegetable origin; our stimulation foods are found in both animals and plants; the constipation-preventing foods and the reducing foods come very largely from the vegetable stuffs.

Tables of foods. In closing the discussion of this first important question as to *what* we should eat, certain common articles of dietary will be listed in tables according to the purpose that they most successfully serve. Those in the first column serve the given purpose in very high degree.

I. GROWTH FOODS

Cheese	Beef	Ice cream
Eggs	Cream	Pork
Liver	Fish	Veal
Milk	Fowl	

II. Fuel Foods

Bacon
Butter
Cheese
Doughnuts
Nuts
Oleomargarine
Olive oil
Beans
Bread, Graham
Bread, white flour
Bread, whole wheat
Candy
Cookies
Corn bread
Crackers
Cream
Dates
Figs
Grapenuts
Ham
Herring
Honey
Jams
Jellies
Macaroni
Mutton
Oatmeal
Olives, ripe
Peas, dry
Pork
Prunes
Raisins
Rice
Shredded Wheat
Sugar

III. Stimulation Foods

Bran
Brussels sprouts
Cabbage
Dandelions
Grapefruit
Lemons
Lettuce
Liver
Oranges
Parsley
Spinach
Tomatoes
Apples
Apricots
Asparagus
Beans, string
Beet tops
Blackberries
Blueberries
Bread, Graham
Bread, whole wheat
Butter
Celery
Cheese
Cherries
Cream
Currants
Dates
Eggs
Figs
Grapenuts
Grapes
Milk
Oatmeal
Onions
Peaches
Pears
Peas, green
Pineapple
Plums
Prunes
Raisins
Raspberries
Rhubarb
Shredded Wheat
Strawberries
Turnips

IV. FOODS TO PREVENT CONSTIPATION

- Bran
- Bread, Graham
- Bread, whole wheat
- Figs
- Prunes
- Raisins

- Asparagus
- Beans, string
- Beets
- Blackberries
- Blueberries
- Cabbage
- Celery
- Cranberries
- Currants
- Dates

- Grapes
- Grapefruit
- Lemons
- Lettuce
- Oranges
- Raspberries
- Rhubarb
- Spinach
- Strawberries

V. REDUCING FOODS

- Asparagus
- Beans, string
- Bran
- Cabbage
- Cantaloupe
- Celery
- Cucumbers
- Eggs, white of
- Gelatin
- Lemons
- Lettuce
- Parsley
- Spinach
- Tomatoes
- Watermelon

- Apples
- Apricots
- Beets
- Blackberries
- Blueberries
- Cherries
- Clams
- Cranberries
- Eggs
- Grapefruit
- Milk
- Onions

- Oranges
- Oysters
- Peaches
- Pineapple
- Pumpkin
- Radishes
- Raspberries
- Rhubarb
- Squash
- Strawberries
- Turnips

NOTE: Limiting starchy food to one variety — as wheat, oats, or potatoes — tends to reduce weight.

THE QUANTITY OF FOOD NEEDED

Our next question of *how much* food a person should eat is a practical one that concerns us at every meal. In answering this question we may consider it with reference to (1) the number of calories the body needs and (2) the amount of protein it needs.

Number of calories needed. We learned in Chapter II that a calorie is the amount of heat necessary to raise the temperature of one gram of water one degree Centigrade. This is known as the small calorie. In measuring foodstuffs the large calorie is used, which is the amount of heat necessary to raise the temperature of one kilogram (a little more than two pounds) of water one degree Centigrade. The number of calories used under varying circumstances has been accurately measured by means of a calorimeter. This is an apparatus so arranged that it will measure the amount of heat given off during the various activities of a person confined in a small room. When a person is at rest, the activities of the vital organs (heart, lungs, etc.) require a certain number of calories. For this purpose about twelve calories a day for each pound of body weight are needed, or about eighteen hundred calories for a man weighing 150 pounds. This is the fundamental requirement for every dietary. All other muscular work requires additional food in order to furnish extra calories, the amount of food needed depending on the kind and amount of exercise.

The number of calories required by a person depends on four factors: weight, functional activity, sex, and age. The larger a person the more food he needs, if the weight is due to bones and muscle tissue and not to excessive fat. The number of calories depends very noticeably on the activity of the person. It increases rapidly as the work done becomes more severe. Exercise is often classified into four groups: light, moderate, active, and severe. Men of inactive occupations, such as teachers and bookkeepers, take light exercise; mail-carriers and carpenters, moderate exercise; farmers and blacksmiths, active exercise; soldiers and lumbermen, severe exercise. The following table shows how the number of calories depends on the exercise.

Kinds of Activity	Calories per Pound per Hour
Sleeping	0.5
Sitting quietly	0.6
Standing	0.75
Light exercise	1.0
Moderate exercise	1.25–1.5
Active exercise	1.75–2.0
Severe exercise	3.0 or more

The number of calories needed by persons under varying conditions of activity has been closely determined, and there is quite general agreement on the essential number for heat requirements. This is shown in the following table:

DAILY CALORIC REQUIREMENTS

For Adults

Occupation	Calories per Pound of Weight	Total for Man of 150 Pounds (Approximate)
Sedentary (professional man)	17	2,500
Moderate exercise (carpenter)	20	3,000
Active (farmer)	24	3,500
Severe (soldier)	27	4,000

For Boys and Girls

Age	Calories per Pound of Weight
14 years old	24
15 years old	22
16 years old	20
17 years old	18

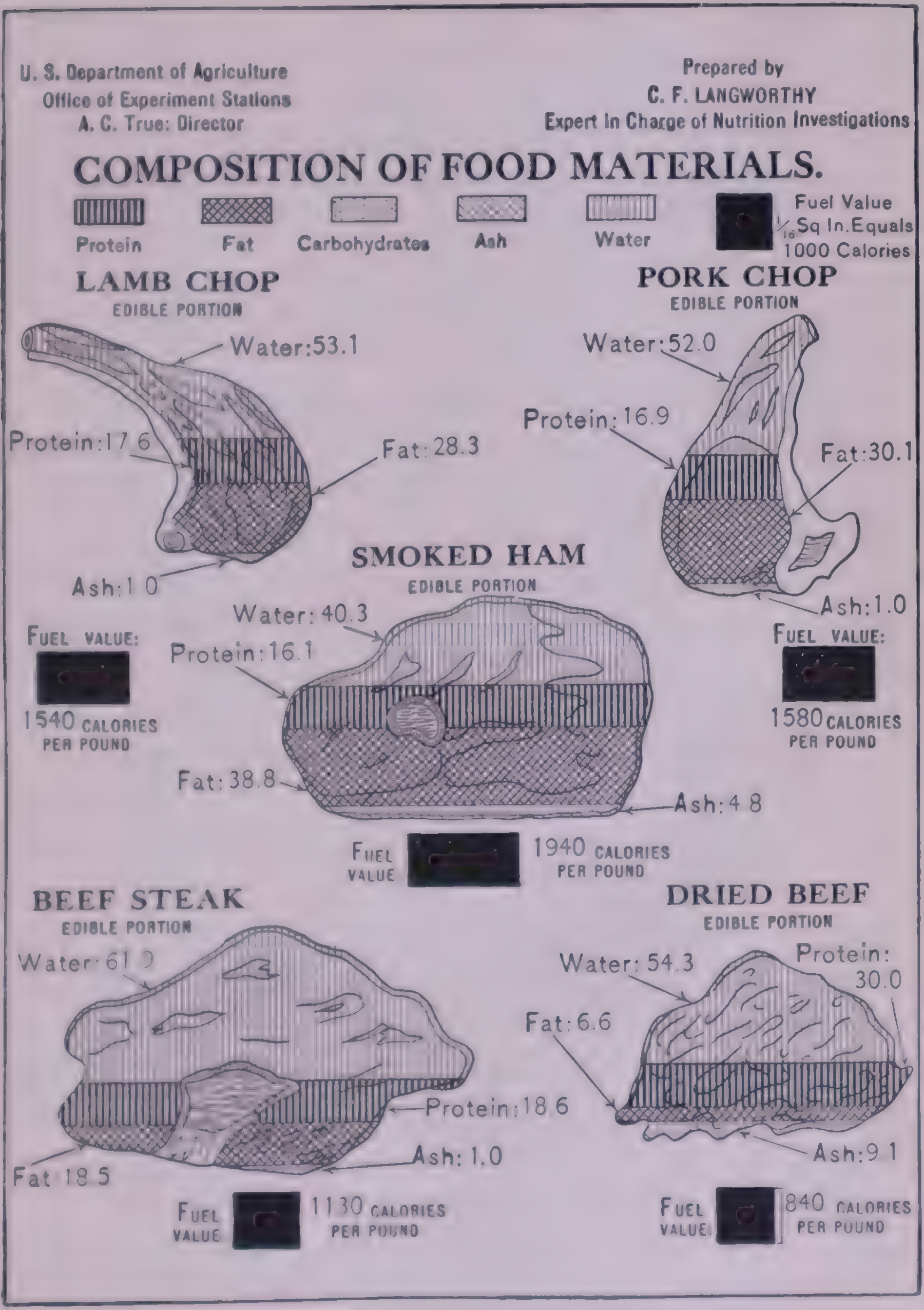

Fig. 39. — Composition of meats

A person may find his caloric requirement by multiplying his weight by the appropriate figure in the above table. Women usually require less than men because they weigh less and perform less vigorous work. They require more relatively to their weight and size because they are larger losers of heat.

More calories in proportion to the weight are needed by children than by adults, because the children are growing. For the two-year-old child, about forty calories per pound are required. This number gradually decreases to about twenty calories at the age of sixteen.

In old age the number of calories needed is less than during middle age. This decrease runs from 10 per cent less at sixty years of age to 30 per cent less for those over eighty years of age.

Protein requirements. Having noted the heat requirements of the body, we may next ask how much protein food the body needs. While protein, as well as fats and carbohydrates, furnishes energy, it is better to meet these heat requirements through the use of fats and carbohydrates and to provide protein only for the growth and repair of the body tissues. The protein requirement depends on two factors — weight and age.

While there is quite general agreement among authorities regarding the number of calories needed by the body, there is a difference of opinion regarding the amount of protein needed. There are two groups of people, one favoring a low-protein dietary and the other favoring a high-protein dietary. The standard set by the first group for a man weighing 150 pounds is 60 grams (about 2 ounces) daily; the standard set by the second group is 100 grams (about 3½ ounces).

Chittenden's experiments. Professor Chittenden, of Yale University, in 1903 and 1904 carried on a series of experiments to test the effect of a low-protein dietary. He selected for this purpose men representing a variety of occupations: soldiers, college athletes, and college professors. The experiment lasted

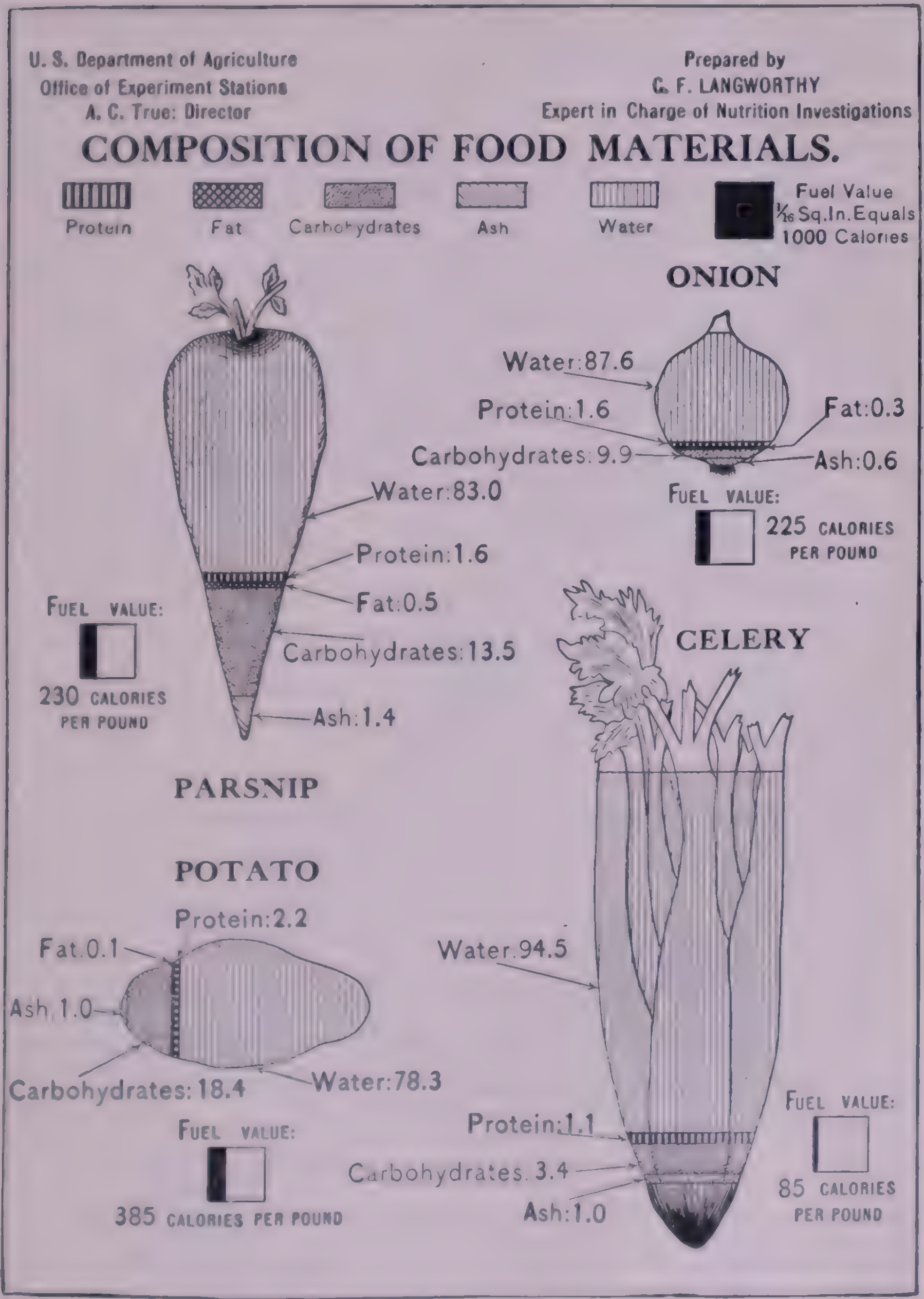

Fig. 40. — Composition of vegetables

six months. During the first month the food proportions were gradually changed so as to include smaller quantities of proteins, until during the last five months the dietary contained less than half as much protein as did the diet to which the men had been accustomed. During this period the men retained their bodily weight, improved in general health, and showed a remarkable gain in strength.

Fisher's experiments. Another set of experiments was carried on at Yale by Professor Fisher. His purpose was to test Mr. Fletcher's claim that thorough mastication combined with obedience to appetite leads naturally to the selection of the proper proportions of food. The results have a bearing on the question of the protein requirement. Nine students took part in the experiment, which lasted five months. Two rules were followed: first, to masticate the food thoroughly; and second, to follow the appetite regarding the amount and kinds of food eaten. At the end of the experiment it was found that the students were eating only one half as much protein as they had been accustomed to eat. Tests of endurance were made both at the beginning and at the close of the experiment, and it was found that at the end there was an enormous increase in staying power. The men noticed, too, a general improvement in health and mental ability.

The experiments of Chittenden and Fisher show that men can live on a low-protein diet and remain in good health or even improve in health and physical condition.

The other group of scientists, which favors a high-protein diet, points to the dietetic studies made in many countries of people who are living on a high-protein diet. They claim that while a person can live on a low-protein diet, it is dangerous to health to continue to do so for long periods of time.

There seems to be a general tendency to take a position midway between these extreme views — to avoid on the one

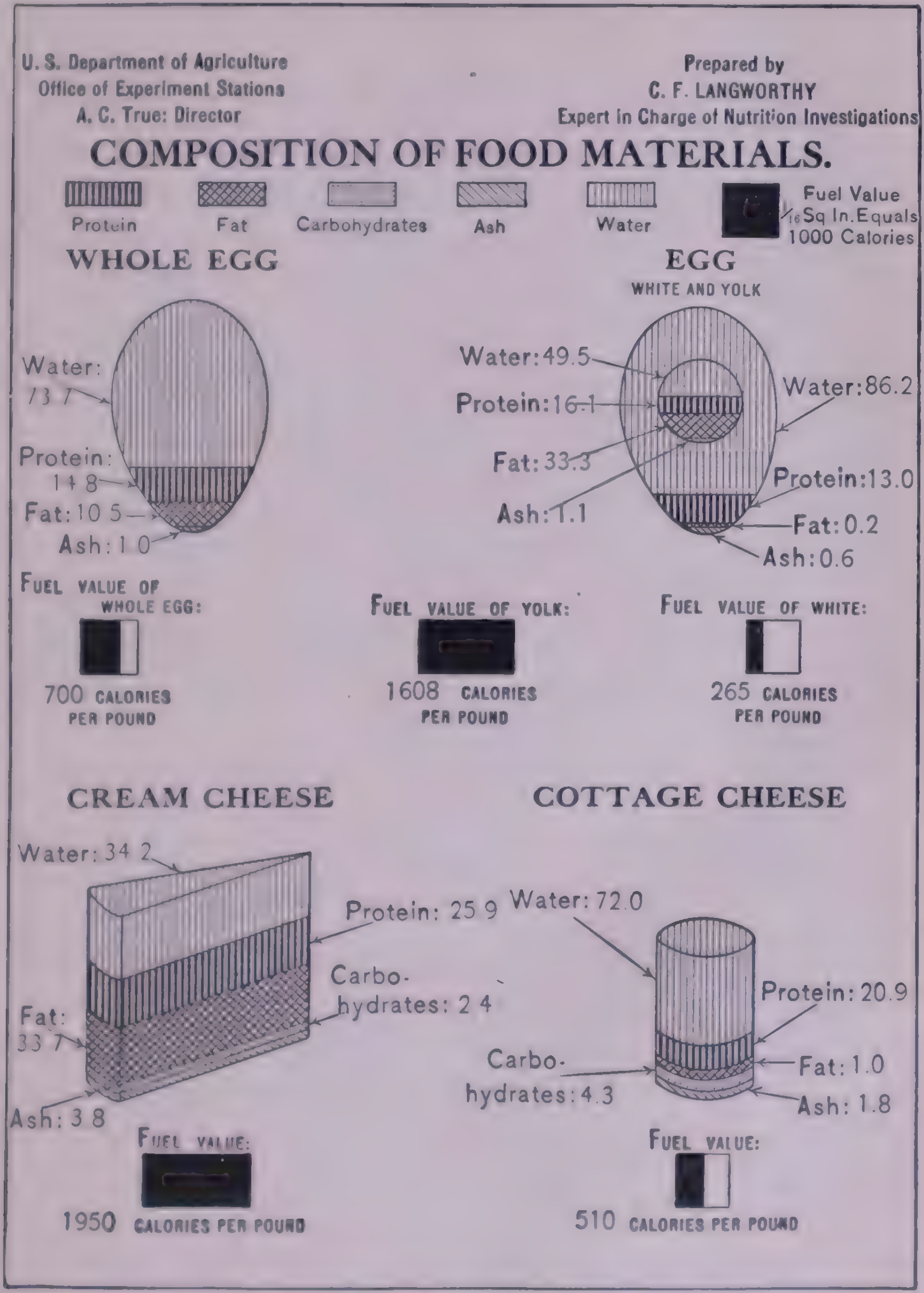

Fig. 41. — Composition of eggs and cheese

hand the possible danger of a lack of sufficient protein, and on the other hand to avoid the dangers of an excessive use of protein, as in too free indulgence in meat. Between the two extremes of 60 grams and 100 grams as the daily requirement of protein, a standard is being set of 75 grams for a man of 150 pounds — that is, one half gram of protein for each pound of body weight. Thus an adult may find his protein requirement in grams by multiplying his weight by one half.

Children, on account of the formation of new tissues, require a larger proportion of protein relatively to their weight. Their requirement ranges between one gram and three quarters of a gram for each pound of body weight.

Determination of adequacy of diet. After a standard has been set as to how much protein and how many calories a person needs daily, how may he know whether his diet approximates this standard? The answer to this question may be determined in three ways: by his weight; by the use of food tables; and to a certain extent by his appetite.

Weight as a guide. One method that gives some indication of the correctness of the dietary is to note a person's weight in comparison with the average for the given height and age. If a person is very much overweight, it suggests that he is eating too much food. A reduction in weight should be brought about gradually, and in some cases it may be advisable to consult a physician. Plumpness should not be confused with fatness. It is quite desirable that children should be a trifle overweight. Usually boys and girls need to be more concerned with weighing too little than with weighing too much.

If a boy or girl is underweight, the dietary should be carefully looked into. This condition may be due either to improper kinds or to insufficient amounts of food. Some expert advice should be sought.

Use of food tables. Some help in regulating the food habits

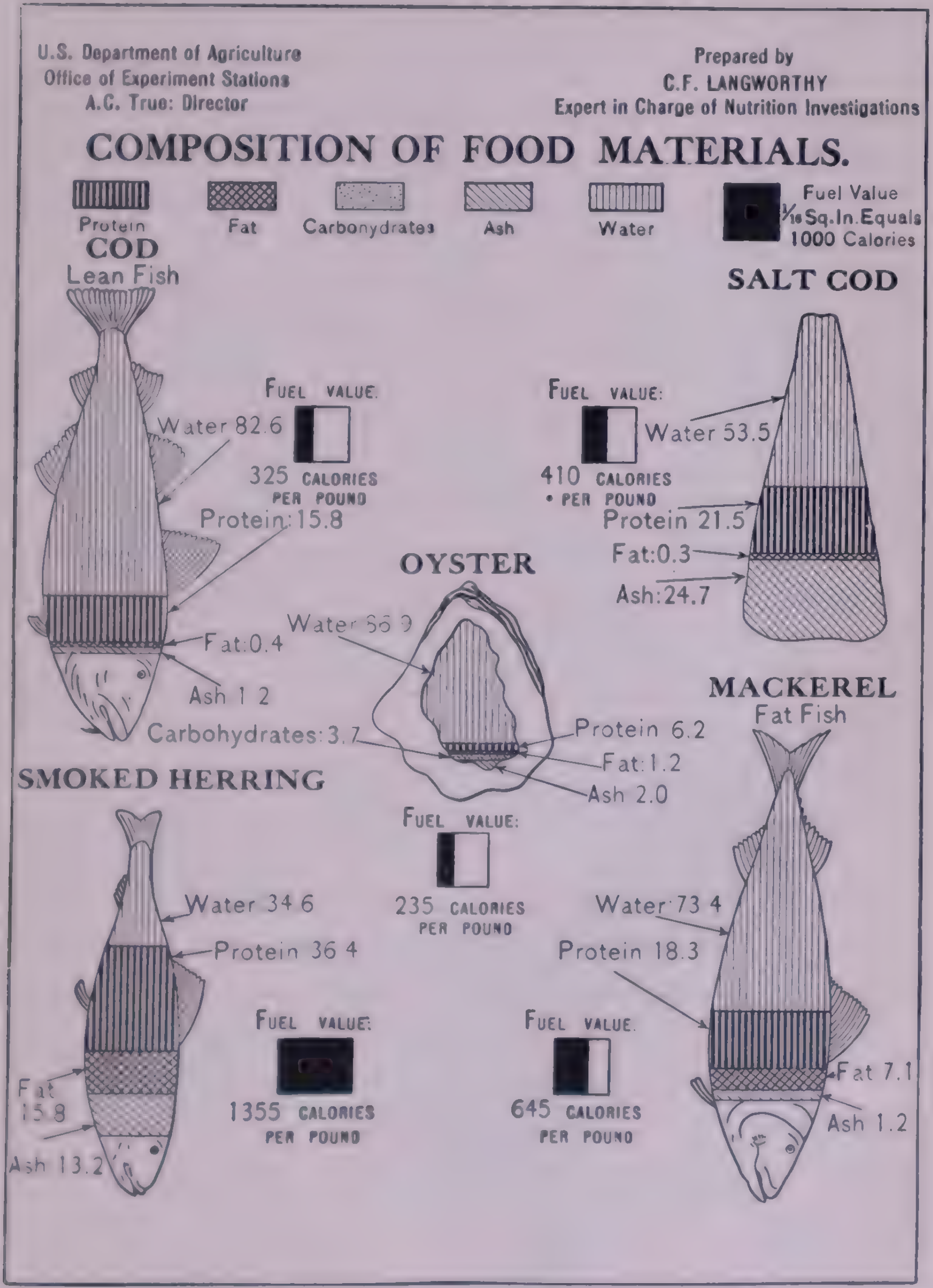

Fig. 42. — Composition of fish

may be secured by consulting tables giving the protein and the fuel value of common foods. If one is troubled with constipation, the table on page 106 will prove especially helpful.

Appetite as a guide. One of the common methods of determining the amount of food one needs is to eat till the appetite is satisfied. But we may well ask whether the appetite is a safe guide. Probably in the very earliest times this was nature's method. But in these days of civilization with its many specially prepared foods we may well doubt whether the average appetite is a safe guide.

One suggestion that may help towards making the appetite a safer guide is to acquire the habit of thorough mastication of food — that is, the food should be chewed till it becomes so fine that it naturally passes down the throat without conscious effort of swallowing. Full mastication tends to save one from the dangers of overeating, for the following reasons: First, because it exhausts the appetite for food more quickly by means of the more strenuous labor of mastication; and second, because, by the thorough breaking up of the foods, it makes digestion easier — especially digestion of protein-containing foods — and makes their nutrients therefore more available.

However, even when thorough mastication is practiced, a person should be guided also by general principles regarding the kind and amount of foods that the body needs.

A few general suggestions are given in the following table:

FOODS TO BE EATEN FREELY	FOODS TO BE EATEN MODERATELY	FOODS TO BE EATEN SPARINGLY
Fresh fruits	Meat	Pies
Fresh vegetables	Fish	Doughnuts
Milk	Ice cream	Cakes
	Cereals	Rich puddings
		Candy

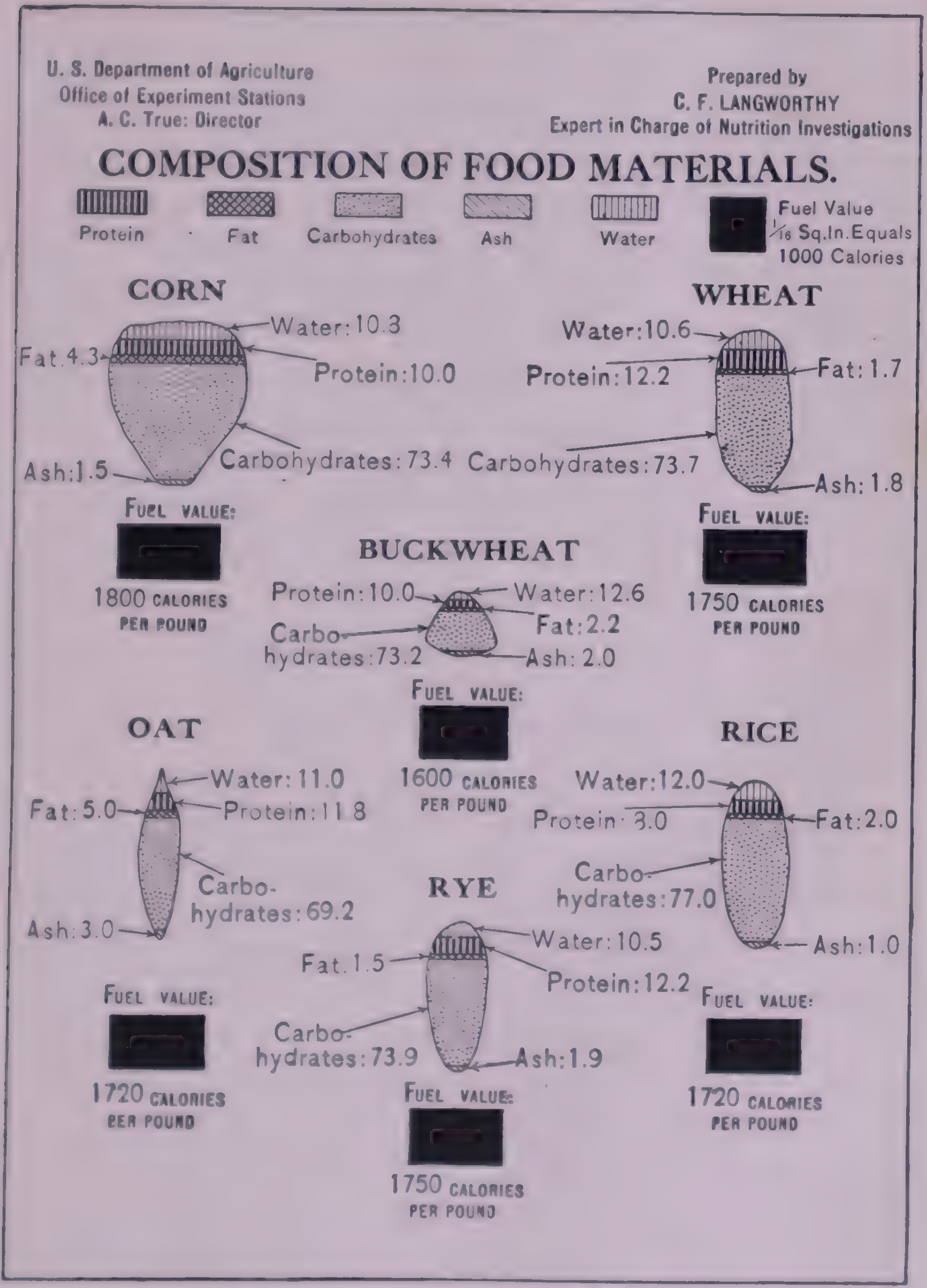

Fig. 43. — Composition of cereals

MASTICATION OF FOODS

Digestion of foods. Since mastication is the first step in the digestion of food and since this influences the later stages of the process, it will be fitting at this time to make a brief study of the process of digestion. Before the foods can be used in the body, they must go through a process of digestion by means of which they are changed into a soluble form which can then be absorbed into the blood.

The process of digestion begins in the mouth, where the saliva acts on the starches, changing them into dextrins and sugar.

In the stomach the gastric juice acts on the protein, changing it to a soluble form known as peptone. Here the food is thoroughly worked over and reduced to a fine semiliquid state before it passes on to the small intestine.

Just after the food leaves the stomach it comes in contact, in the small intestine, with the pancreatic juice, which has the power of digesting all three kinds of nutrients. It finishes the work begun by the saliva in digesting the starches and that begun by the stomach in digesting the proteins; and in addition, with the aid of bile from the liver, it digests the fats.

In the small intestine, ferments are formed which serve to split the more complex sugars into the simpler sugars, a change which permits their absorption.

Absorption of foods. After the foods are digested, they are absorbed through the walls of the intestine and carried by the blood to the various parts of the body, where they are used. The waste products resulting from the oxidation of foods are given off by the various excretory organs of the body. The carbon dioxide and some of the water resulting from the burning of the food pass off through the lungs.

Exercise and digestion. The subjects of exercise and digestion are closely related. One of the chief values resulting from

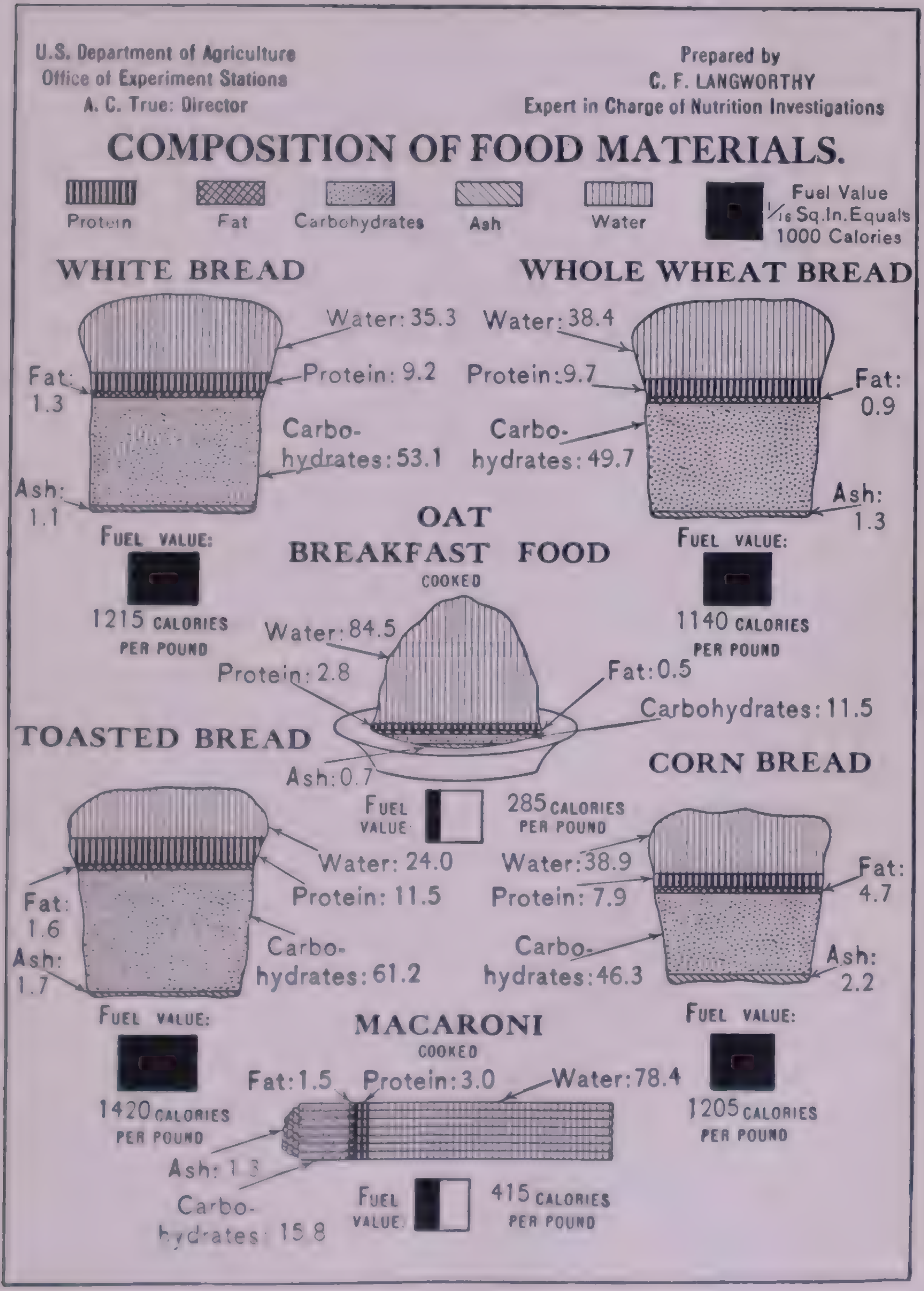

Fig. 44. — Composition of bread

exercise lies in the beneficial result that it has on the process of digestion. It is a well-known fact that those people who are doing heavy muscular work are less afflicted with digestive troubles than those who secure little muscular exercise. People who change their occupations or habits to those that require less muscular effort find that their general health is much poorer. It is specially important for those living an inactive life that some form of exercise, preferably out of doors, should be taken regularly, to insure the proper working of the digestive system as well as of the other systems of the body.

Methods of eating. Since mastication is the only part of the digestive process that is under our control and since it affects the later stages of digestion, it is essential that the work should be well done; that is, the food should be thoroughly and completely masticated. This mastication prepares the food for swallowing; it breaks it up into small particles so that the digestive juices of the stomach can act upon it more readily; it increases the flow of the gastric juice; and it mixes the saliva with the food so that the process of starch digestion begins.

Care of the teeth. Since thorough mastication of food is so important a factor in its effect on health, we can understand how necessary it is that the teeth should be well cared for, so that they may be preserved in good condition to perform the work of mastication.

There are three factors concerned in the decay of teeth: first, the food particles that lodge between the teeth; second, the bacteria that act on these food particles; and third, the acids produced as a result of this action. These acids act on the teeth and produce decay. To prevent this decay, a person should see to it that particles of food are not allowed to remain between the teeth.

The first step in the care of the teeth is thorough mastication, which leaves the teeth cleaner than does insufficient mastication. The larger pieces of food may be removed by means of toothpicks or dental floss, and the smaller particles require the use of a toothbrush. The best time to brush the teeth, if it is done but once a day, is after the evening meal. Otherwise the food particles would remain in the teeth during all the night, thus allowing a long time for the action of the bacteria in producing decay. However, while the teeth should be cleaned at least once a day, the best care requires another cleansing after the morning meal.

GENERAL SUGGESTIONS

Drinking water. Water should be drunk freely many times a day. Recent experiments have shown that drinking water with the meals really helps the process of digestion instead of hindering it, as has sometimes been thought. Water should not be taken, however, when the mouth contains food, to serve as a substitute for mastication, washing down foods that are only partially masticated. Under ordinary conditions, a person needs about two glasses of water at each meal and two glasses between meals, or eight glasses a day — the equivalent of about two quarts. Other drinks, such as milk, tea, and coffee, furnish a part of the needed water.

Tea and coffee. There are some drinks very commonly used at the table that have sometimes been carelessly called foods — namely, coffee and tea. These are not foods in any sense of the word. Both are stimulants that act as spurs to the nervous system and thus increase its activities. This stimulating effect is due to certain drugs found in tea and coffee. Both beverages also contain tannic acid, which may be harmful to the membrane lining the stomach. Since tannic acid does not dissolve readily in water, the effects of tea are less harmful if the water is not allowed to boil after the tea is made.

Neither tea nor coffee serves any necessary function in the body. The effect of these drinks on adults varies greatly with different people. Some people are distinctly harmed by their use, while others use them without any apparent injury. But whatever may be said about their effect on adults, all authorities agree that they are injurious to growing boys and girls, who are better off if they leave these drinks entirely alone.

COST OF FOODS

Buying foods. Now that we have determined what foods contain the nutrients the body needs, the next problem is to ascertain what foods give the largest amount of nutrients for the least cost. The cheapest foods cannot always be determined by comparing the price per pound or quart, for we must know also the proportions of nutrients that the foods contain.

People are often misled by the idea that the higher the price paid, the better the article purchased. This idea is entirely wrong as applied to foods. The price of foods is not determined by the nutrients they contain, but largely by other factors such as rarity, appearance, tenderness, flavor, or cost of production — factors that influence only slightly the real value of foods. For illustration, take the case of sirloin and round steaks. Sirloin costs more, chiefly because it is more tender, and yet it contains more waste and less protein; hence it is really not so valuable a food as round steak.

If we compare fresh codfish with oysters, we find a much higher price is charged for oysters, largely on account of their flavor and rarity; yet if the same amount of money be invested in both, twice as much food material and three times as much protein will be obtained in the codfish as in the oysters.

A man who made a careful study of portions of food served in New York City found that five cents invested in a roast-beef sandwich bought 358 calories, while five cents invested in raw oysters bought only 19 calories; that is, the sandwich furnished eighteen times as many calories as the oysters, and yet they each cost the same sum.

Economy of cooking. Proper methods of cooking may aid much in food economy. Frequently the more costly cuts of meat are more expensive simply because they are more tender, while they are not more nourishing than the cheaper meats, which, by proper methods of cooking, may be made tender and palatable. Another economic measure lies in the treatment of food after it is purchased. The bones and trimmings of meat contain appreciable amounts of nourishment, and these may be used in soups and stews, instead of being thrown away as they often are.

Storing eggs. Another economic device is to buy foods when they are abundant and cheap and store them for later use. This plan may be followed easily with eggs. These are most abundant and cheapest during the spring and early summer; they may be secured then and stored for winter use. Water glass has proved to be the best substance to use in storing eggs. This is used in the proportion of one part of water glass to ten parts of water. The water should first be boiled and allowed to cool. A quart of water glass will make enough mixture to cover from fifteen to twenty dozen eggs. The cost of the mixture averages about three cents per dozen eggs, not counting the cost of the containers, of which earthenware crocks or wooden pails are the most satisfactory. The solution may be poured into the container and the eggs added as they are collected. Only fresh, clean eggs should be used. The container should be covered and stored in a cool, dry cellar.

EVACUATION OF BOWELS

There are certain portions of the food that cannot be digested, and health requires regularity in the removal of these wastes at least once a day; a regular time is not less important than regular times for meals. Constipation may result from any one of several causes, such as lack of exercise, and the eating of improper kinds of foods. Since constipation may lead to serious results, it should not be allowed to continue without steps being taken to remedy it. The following are measures that may be taken: (1) Foods should be eaten that are known to prevent constipation through the vegetable fibers that they contain (see page 106). Among the best are bran, prunes, figs, raisins, whole wheat and Graham bread, fresh fruits, and fresh vegetables. This attention to food quality is the best way of preventing constipation. (2) A person should take regular exercise. (3) Mineral oil, which is much superior to ordinary laxatives, may be used. (4) Drinking large quantities of water may be helpful. (5) Glycerine suppositories may sometimes be used.

HOME PROJECT 6

Purpose. To practice daily the proper health habits.

Directions. Copy the following table in your notebook. Try each day to follow out the habits suggested. At the end of each day fill in the blank spaces, giving yourself the credits you deserve according to the faithfulness with which you have practiced each of these habits. At the end of the week have your father or mother sign the report. Then hand it to your instructor as a part of your regular class work.

TABLE OF HEALTH HABITS FOR THE WEEK ENDING [DATE]

	DAILY CREDIT	SUN.	MON.	TUES.	WED.	TH.	F.	SAT.
Clean teeth . . .	19							
Sleep with window open	19							
Retire by 9:30[1] . .	19							
Abstain from use of tea and coffee . . .	19							
Exercise one hour outdoors	19							
Bathe once a week .	5							
Total . . .	100							

I believe that the above record is a truthful account of my child's health habits for the week. (To be signed by parent)

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[1] The time will vary according to the age of the child.

OUTLINE SUMMARY

THE HYGIENE OF THE DINING ROOM

- I. The selection of foods
  - 1. Uses of foods
  - 2. Classification of foods according to composition
    - *a.* Uses of nutrients
    - *b.* Vitamines
    - *c.* Sources of proteins
    - *d.* Sources of fats and carbohydrates
    - *e.* Water
  - 3. Classification of foods according to source
    - *a.* Animal foods
    - *b.* Vegetable foods
    - *c.* The advantage of a mixed dietary
  - 4. Tables of foods
- II. The quantity of food needed
  - 1. Number of calories needed
  - 2. Protein requirements
    - *a.* Chittenden's experiments
    - *b.* Fisher's experiments
  - 3. Determination of adequacy of diet
    - *a.* Weight as a guide
    - *b.* Use of food tables
    - *c.* Appetite as a guide
- III. Mastication of foods
  - 1. Digestion of foods
  - 2. Absorption of foods
  - 3. Exercise and digestion
  - 4. Methods of eating
  - 5. Care of teeth
- IV. General suggestions
  - 1. Drinking water
  - 2. Tea and coffee
- V. Cost of foods
  - 1. Buying foods
  - 2. Economy of cooking
  - 3. Storing eggs
- VI. Evacuation of bowels

QUESTIONS FOR CLASS DISCUSSION

1. Which is better, a mixed diet or a vegetable diet?
2. To what extent should cost be considered in buying foods?
3. How may economy be practiced without injuring the health?
4. How did Professor Chittenden's experiments differ from Professor Fisher's?
5. To what extent are the conclusions of these investigators similar?
6. How may these experiments help us in determining our food habits?
7. What is the chief value of thorough mastication of food?
8. What bearing on health does the care of the teeth have?
9. How does overeating injure health?

REFERENCES

Conley, *Nutrition and Diet.* American Book Co., New York.
Fisher and Fisk, *How to Live.* Funk and Wagnalls Co., New York.
Kinne and Cooley, *Food and Health.* The Macmillan Co., New York.

CHAPTER VIII

SCIENCE OF THE KITCHEN

In what ways are our modern methods of cooking better than the methods used in early times?

Cooking Foods

Purposes of cooking. Man in his early history ate his food uncooked; today civilized man finds that cooking foods serves three important purposes: First, it destroys parasites and disease germs; second, it makes the food more appetizing; and third, it makes the food more digestible.

Sometimes bacteria and parasites that cause disease, such as typhoid fever and trichinosis, are found in foods; the high temperature used in cooking kills these causes of disease and thus renders them harmless. Many foods are made more agreeable to the taste through cooking; and this result has an important effect on the digestion of the food, as it is found that foods that we enjoy are digested better than foods that we dislike.

Many foods are rendered more digestible by cooking. Much of the starch found in vegetable foods is inclosed in tough walls upon which the digestive juices cannot act. Cooking breaks open these walls, thus allowing opportunity for the digestive juices to act on the swollen particles of starch. Cooking softens the tough connective tissues of some meats and thus renders them more tender and more easily digested.

Making bread light. One important quality of good bread and similar foods is that they shall be light and porous. This condition is brought about by mixing some gas with the dough, for as the dough is cooked these gases escape and leave the bread porous. Sometimes this result is produced by mechanically forcing air into the dough by beating. Eggs are sometimes added to render the dough more capable of holding the air. Usually, however, something is put with the dough to produce a gas, which rises through the dough and makes it porous. Gas is produced in dough by using baking powder or yeast, in both cases carbon dioxide gas being formed.

Baking powder. A baking powder is a mixture of two compounds of such nature that when water is added the two chemicals act on each other and carbon dioxide is formed. One of these compounds is usually baking soda; the other may be cream of tartar, phosphate, or alum. A little starch is usually mixed with these to prevent the powder from becoming moist. In place of baking powder, soda and sour milk may be used.

Yeast. Yeast also is used to make bread light. Yeast is a very small plant; a single one is too small to be seen by the eye without the aid of a microscope. As a result of the action of the yeast on dough, carbon dioxide is formed and makes bread light in the same way as the carbon dioxide formed by baking powders. At the same time alcohol is formed, but in the oven this passes off from the bread. When war breads were being made by the use of substitutes for wheat, it was frequently found that the bread was heavy. Wheat contains a sticky substance called gluten, which keeps the dough porous after the gases pass through it. Barley and other wheat substitutes do not contain this gluten; therefore it is necessary to mix a certain amount of wheat with the other flours in order to furnish enough gluten to make a light bread.

DEMONSTRATION 24

Purpose. To study the action of baking powder and yeast.

Materials. Baking powder; baking soda; cream of tartar; vinegar.

Directions. 1. Mix dry baking soda and cream of tartar. Add hot water and note what happens. Add vinegar to baking soda. Put a little baking powder into water and note what happens. Dissolve baking soda and cream of tartar separately in cold water; then pour one into the other. Try again, using hot water, and note the difference.

2. Make a paste of flour and water. Mix with this a small piece of yeast cake. Allow the mixture to stand for a while in a warm place and notice what happens.

3. Put in each of two test tubes or small bottles a teaspoonful of molasses and ten teaspoonfuls of water. Mix a small piece of yeast cake with water and add a half to each bottle. Put one bottle in a cool place, as in an ice chest, and the other in a warm place. At the end of a day notice any difference in the two.

Methods of cooking. Water is an essential factor in cooking. Many foods are cooked in boiling water. This insures an even temperature, as water always boils at the same temperature, 212 degrees, with slight variations due to changes in atmospheric pressure. In the double boiler, the outer dish holds boiling water and the inner dish the food to be cooked. So long as the outer dish contains water, the food will not burn. Sometimes, as in stewing, foods are cooked in water that is kept just below the boiling point.

In cooking meats, if it is desired to keep the juices within the cut, the piece is put directly into boiling water, which forms a coating on the outside that retains the juices within the meat. If it is desired to extract the juices from the meat, as in soup, the meat is put into cold water and then heated gradually; and thus many of the juices mix with the water.

Some foods are cooked in hot fat, since fat can be heated to a temperature much higher than that of boiling water. It should be so hot that when the food is placed in it the outside is heated quickly, forming a coating which prevents the fat from entering the food. When the fat mixes with all portions of a food, a mass is formed that is difficult to digest.

It is seen that these various methods of cooking involve different temperatures. By stewing, foods are cooked at a temperature below 212 degrees; by boiling, at a temperature of 212 degrees; by cooking in hot fat, at a temperature higher than this; and by baking, at a still higher temperature.

Early methods of cooking. It is interesting to note the changes that have occurred in the methods of cooking since the very earliest times. At first, cooking was carried on by broiling over the open fire or by roasting in hot ashes. Later on, crude kinds of kettles were suspended over the fire and the food was cooked by boiling or stewing in these. Then the open fireplace indoors was used, and movable ovens, open at one side, were placed in front of it. Machines were used to turn meats that were roasted in front of open fires. Then various kinds of closed ovens were made. Even within the history of our own country, open fireplaces and brick ovens were the common means of cooking. In more recent times stoves and the gas range have appeared; and now cooking is being done by electricity.

Fireless cooker. The fireless cooker is another device for cooking. It consists of a box with a tightly fitting cover; in the box are several compartments separated by some material that conducts heat slowly, such as hay, excelsior, or mineral wool. The foods to be cooked are first brought to boiling on a stove; then they are placed in these compartments and tightly covered. As there is little opportunity for the heat to escape, the foods continue to cook; and if sufficient time be allowed, they are cooked enough for eating. Pies and bread may be baked and meats roasted. For these purposes heavy plates are heated and set in the bottom of the compartment, and the food is placed on them. If one has access to a gas range or a kerosene stove by which water can be

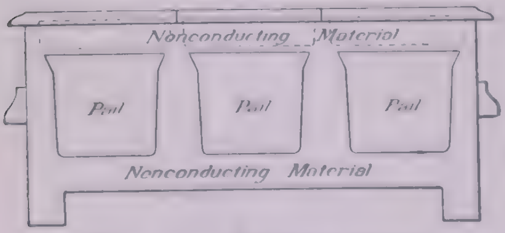

Fig. 45. — Fireless cooker

quickly heated, the fireless cooker has two great advantages, namely, comfort during warm weather and the saving of fuel.

Thermos bottle. The thermos bottle, in which liquids may be kept either hot or cold for a long time, is made on somewhat the same principle as the fireless cooker. It consists of two bottles, one inside the other, separated by a vacuum through which heat cannot pass readily in either direction. The outer surface is made of a bright, smooth material which reflects the heat rays instead of allowing them to pass through.

Fuels used in cooking. One of the most common means of cooking is the wood or coal range. This is so constructed that the heated gases are forced around the oven before escaping up the chimney. Gas ranges are very widely used in towns and cities. The heat can be started, controlled, and shut off at will; and the gas range is especially advantageous during warm weather. The burners are so arranged as to mix air with the gas, thus producing a complete burning which gives a very hot

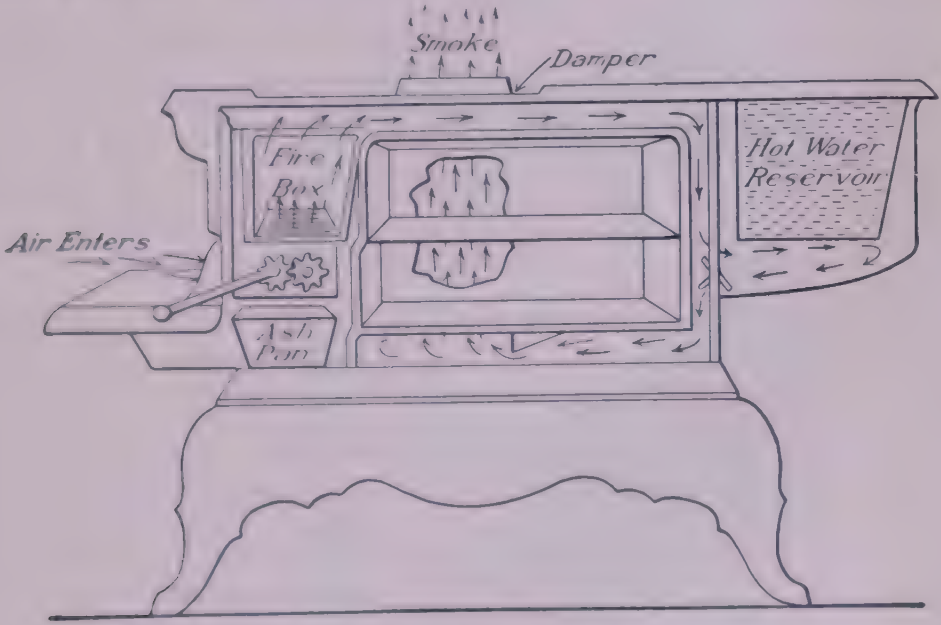

Fig. 46. — A kitchen range

blue flame. Usually these burners are adjustable, so that the proper amount of air may be admitted to give the hottest flame.

LABORATORY EXERCISE 7

Purpose. To study the working of a Bunsen gas burner.

Directions. The burners on a gas range work on the same principle as the Bunsen burner. Take a burner apart, noting the various pieces. Put it together and light the gas. Cover the air holes completely; then leave them wide open. What difference does it make in the flame? Cover the holes partially. How should the burners on a gas range be regulated?

KEEPING LOW TEMPERATURES

Refrigerator. In order to keep foods from decaying in warm weather, the refrigerator is now widely used. The bacteria that cause decay do not thrive at low temperatures; hence food may be kept for some time in refrigerators. Melting ice remains at a temperature of thirty-two degrees till all is melted. The air around the ice is cooled and, being heavier, sinks, and the warm air in the refrigerator comes in to take its place. Thus there is a circulation of air in the refrigerator similar to that which takes place in a room heated by hot air. The walls of the refrigerator are made of

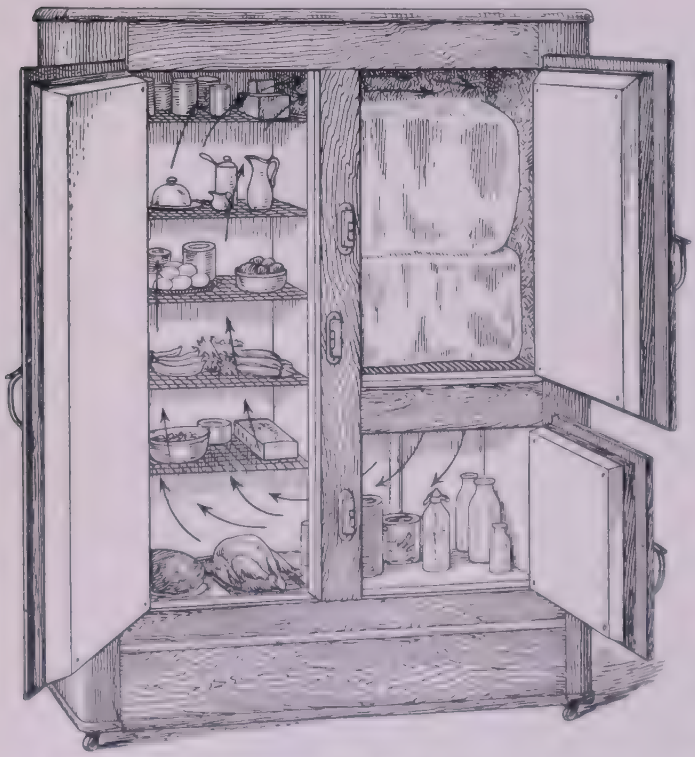

Fig. 47. — Circulation of air in a refrigerator

materials which do not conduct heat easily from the outside; and air spaces are usually left in the walls, as air is a poor conductor of heat.

One of the more recent developments is the electrical refrigerator. The principle involved is that when a liquid changes to a gas, as when water evaporates, the temperature is lowered. Sulphur dioxide, the substance used, under ordinary conditions is a gas, which in this case is compressed to a liquid by means of a motor. Then when the pressure is removed, the liquid changes quickly to a gas, and the temperature is lowered. This part of the refrigerator is called the condensing apparatus. The refrigerating part, consisting of a brine tank and a thermostatic control, fits into the ice chamber of any ordinary refrigerator. The motor is so arranged that it works automatically.

Ice cream freezer. The freezing of cream and other liquids in the preparation of desserts is accomplished in an ice cream freezer. A freezing mixture surrounds the vessel that contains the substance to be frozen. This mixture consists of ice and salt, about three parts of ice to one of salt. Salt has so great an attraction for water that when it is placed in contact with ice it causes the ice to melt. Since heat is required to melt ice, this heat is taken from the surrounding bodies. A temperature may be obtained as low as twenty-five or thirty degrees Fahrenheit below the freezing point — that is, almost down to zero. The brine formed does not freeze, because its freezing point is much lower than that of pure water.

DEMONSTRATION 25

Purpose. To study the principles involved in freezing ice cream.

Materials. Salt; ice; tumbler; thermometer; test tube; tin cup.

Directions. 1. Put a mixture of salt and crushed ice in a tumbler. Put in this the bulb of a thermometer and record the temperature. Try different proportions of ice and salt and find which gives the lowest temperature.

2. Put a test tube containing water into the mixture of ice and salt.

3. Fill a tin cup with snow. Place the cup on a board covered with a layer of water. Stir some salt into the snow. What happens to the water on the board and on the bottom of the cup? Why?

PRESERVING FOODS

Causes of decay of foods. One common problem in the home is to keep foods from decaying. The decay of foods is caused chiefly by the action of three small plants: molds, bacteria, and yeasts. Molds may be seen with the naked eye as threadlike plants growing upon various kinds of food. On these threads appear little stalks, each bearing a ball. These balls are filled with a powder called spores; the spores are scattered about and then grow into new plants. Since these molds have no green coloring matter, they cannot make their own food like ordinary plants, but must live on food already made by other means.

Bacteria are the smallest plants known and can be seen only with a microscope. They multiply so rapidly that a few may develop in a short time into an enormous number. Both molds and bacteria require moisture and warmth in order to grow.

DEMONSTRATION 26

Purpose. To study the activities of bacteria and some means of controlling them.

Materials. Test tubes; raw meat; beans; boiled potato; white of egg; salt; vinegar; formalin.

Directions. 1. The action of bacteria in causing decay:

a. Place in a test tube a small piece of raw meat; half cover it with water. Set it in a warm place for two or three days. Note the appearance of both meat and water. The change has been caused by bacteria.

b. With a knife heated in a flame, cut a boiled potato into two parts. On one half of the potato put some dust; leave the other half untouched. Cover them both and allow them to stand for several days. Note any difference.

2. Effect of drying on the activities of bacteria:

In one tube place a bean, in another a bean half covered with water. Allow them to stand for a week; then note any difference between the two.

3. Effect of freezing and boiling:

Put a small piece of raw meat in each of three test tubes; nearly cover with warm water. Boil the water in one tube. Plug all three tubes with cotton batting. One of the tubes that has not been heated should be placed outdoors where it will freeze; keep the other in the schoolroom by the side of the one that has been heated. On the next day bring in the tube from outdoors and allow all three tubes to stand in the schoolroom for several days. Note any differences. What is shown about the effect of high and low temperature on the growth of bacteria?

4. Effects of salt, sugar, vinegar, and formalin:

Mix the white of an egg with about ten times its bulk of water. Pour some of the mixture into each of five test tubes. Allow the first tube to remain as it is; to the second, add a little salt; to the third, a little sugar; to the fourth, some vinegar; and to the fifth, three drops of formalin. Allow to stand side by side for several days, and note any differences in the effect of the substances in preventing decay

Drying. Many methods of keeping foods for long periods of time are used; among the more common are drying, smoking, using preservatives, and canning. Drying was one of the earliest methods used. Bacteria and molds that cause decay require a certain amount of moisture in order to live, and by drying foods the amount of water may be reduced to such a limit that the bacteria and molds cannot live. Many foods are already dried as we harvest them, such as peas, beans, corn, and the various kinds of grains. The foods obtained from these by grinding, such as flour and

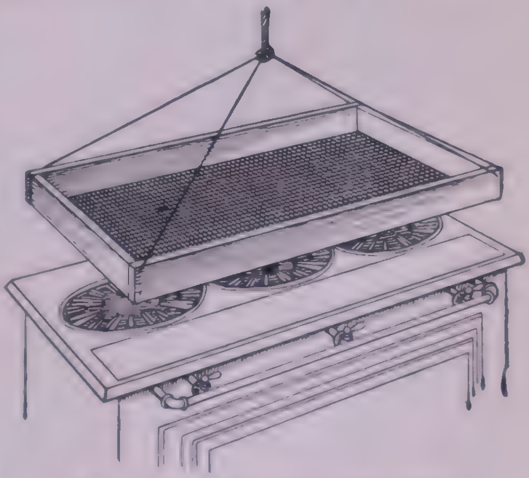

Fig. 48. — Home-made drier

meal, can be safely kept. In other cases artificial drying is used. For some uses even milk is evaporated and reduced to a dry powder that may be kept for a long time.

Preservatives. Some foods are preserved by the use of salt or sugar. Oftentimes preservatives are used in connection with the process of drying — salt with meats, and sugar with fruits and berries, such as raisins and prunes. The smoking of hams and other meats is often accompanied by two other processes, drying and salting. Another harmless preservative that may be used is vinegar, the acid quality of which prevents the growth of bacteria that produce decay. Sometimes spices are used to help to preserve foods, as in mincemeat and sausages.

Canning. One of the most widely used methods of preserving foods is canning. This is now such an important industry that the most of our common fruits and vegetables can be bought canned. Canning has proved a great blessing to mankind, since foods that keep for only a short time in the fresh state can now be obtained at any season of the year. It is also a means of economy in the home. Vegetables can be raised in the garden and then canned for winter use. This canning may be done at slight cost, and one is sure of the quality of the products canned.

In canning, two main principles are involved: First, all those plants which cause decay that are present in the substances to be canned and in the jars must be killed; and second, the cans must be sealed in such a way that no other plants of the kind can enter.

Killing the bacteria. The most difficult plants to kill are bacteria. The method usually employed in the home to kill these bacteria is to heat the jars at the temperature of boiling water for a period varying from fifteen minutes to three hours, depending on the product to be canned. In addition to the active forms in which bacteria are generally found, some — known

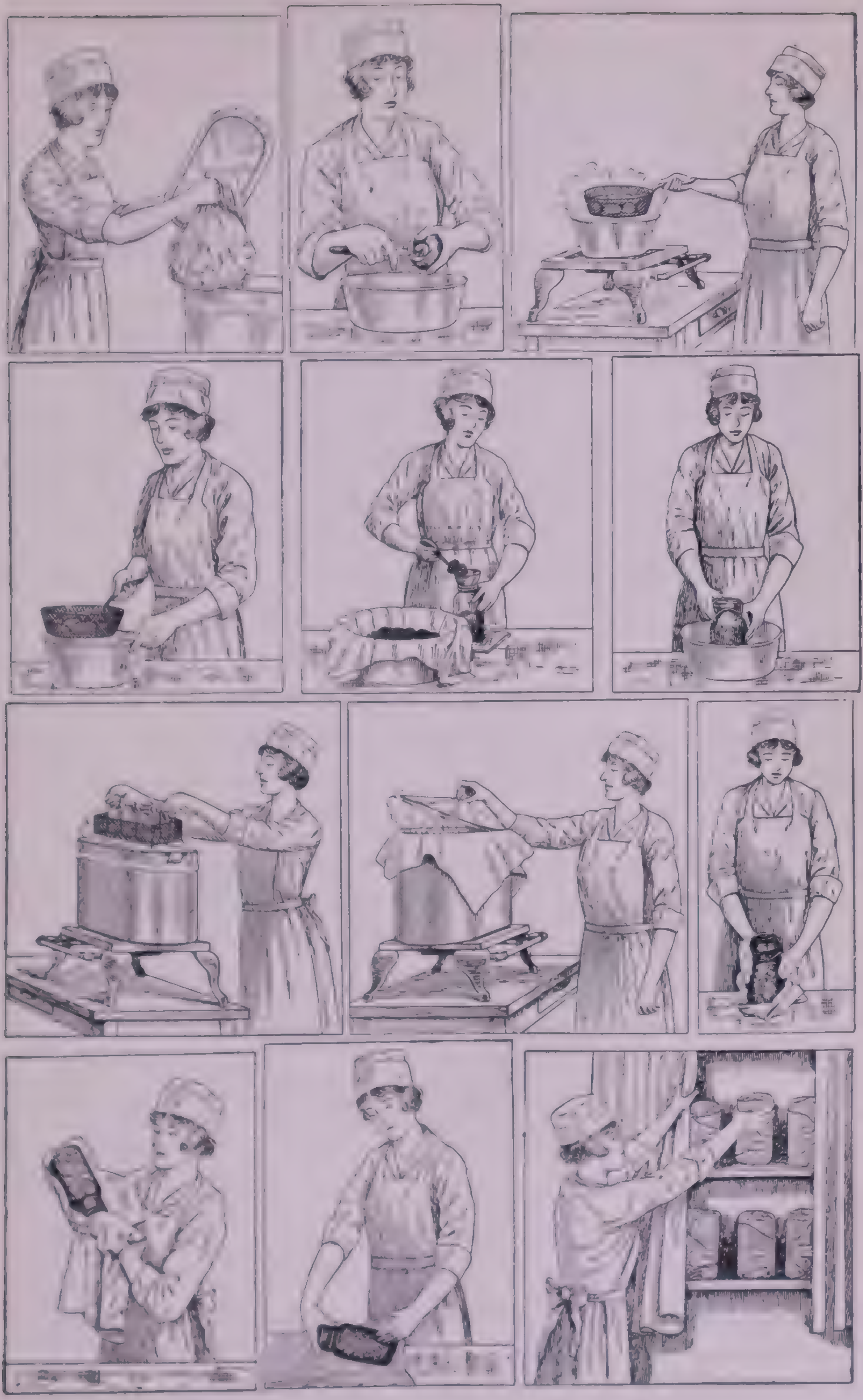

Fig. 49. — Steps in canning

as spores — exist in a resting state. While the active form is easily killed by a short boiling, a longer boiling is necessary in order to kill the spores. Fruits are easily canned; vegetables require more care. Lack of success in canning vegetables is often due to failure to boil long enough to kill the spores.

Cold pack method of canning. The process of canning has now been made so simple that it can be carried on in the home with inexpensive apparatus. The first steps are the preparation of the products to be canned and the cleaning of the containers. It is better to can the products within a few hours after they are picked. For home use, glass jars are best. The jars should be thoroughly cleaned and kept in a dish of hot water.

In the cold pack method, there are five steps: (1) blanching, (2) cold dipping, (3) packing, (4) processing, and (5) sealing. Blanching consists in putting the products into boiling water and allowing them to remain for a few minutes. This time varies from one to fifteen minutes, depending on the kind of product. The purpose of blanching in some cases is to loosen the skins, as with tomatoes; in other cases the purpose is to reduce the bulk of the vegetable. The products may be placed in a piece of cheesecloth or in a wire basket made for the purpose. Blanching is omitted in canning berries and soft fruits.

The cold dip serves three purposes: (1) to harden the pulp under the skin so that the skin can be removed; (2) to set the coloring matter; and (3) to make it easier to handle the products in packing.

After dipping, the products are packed in hot jars. Sirups are added to fruits, and hot water to vegetables. For seasoning, a level teaspoonful of salt is added to each quart of vegetables. The covers are put on and partially closed, and the jars are then placed in some vessel for processing, which consists in heating the jars so as to kill bacteria. The time depends on the kind of product and the temperature. The simplest device for home use is the hot-water bath outfit. This consists of any receptacle in which water can be boiled. It must be deeper than the height of the jar, so that the jar may be completely covered with water. Such utensils as wash boilers, lard pails, and tin pails can be used.

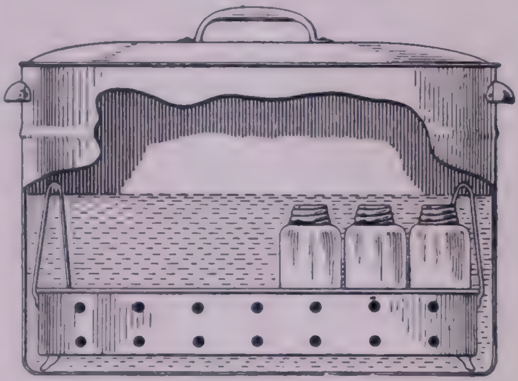
Fig. 50. — Boiler for canning

Some kind of platform with holes through it should be placed on the bottom of the utensil so as to permit the free circulation of water around and under the jars. The water should cover the tops of the jars by at least an inch. The receptacle should have a tightly fitting cover. After the processing is finished, the jars are removed and sealed tightly at once.

Canning under pressure. Canning is done also by steam-pressure outfits. Pressure so raises the boiling point of water that under a pressure of five pounds the boiling point is 228 degrees, and under a pressure of fifteen pounds it is 250 degrees. When the products are heated at these high temperatures, a shorter time is required. Under a pressure of ten pounds, only one half to one third as long a period is required as with the hot-water outfit. In commercial canning factories these pressure outfits are used altogether. Small outfits for home use can be obtained at prices ranging from fifteen dollars up

The following table shows the time required for scalding and processing a few common vegetables and fruits both with the hot-water outfit and with the pressure outfit.

TIME-TABLE FOR BLANCHING AND STERILIZING VEGETABLES AND FRUITS

VEGETABLES AND FRUITS	BLANCHING	STERILIZING		
		Hot-Water Outfit	Steam Pressure 5–10 Pounds	Steam Pressure 10–15 Pounds
Vegetables	*Minutes*	*Minutes*	*Minutes*	*Minutes*
Asparagus	15	120	60	40
Beans, wax	5–10	120	60	40
Beets	5	90	60	40
Corn, sweet	5	180	90	60
Peas	5–10	180	60	40
Spinach	15	120	60	40
Squash	3	120	60	40
Tomatoes	1.5	22	15	10
Fruits				
Apples	1.5	20	8	6
Cherries	..	16	10	5
Peaches	1–2	16	10	5
Pears	1.5	20	8	6
Plums	..	16	10	5
Raspberries	..	16	10	5
Strawberries	..	16	10	5

DEMONSTRATION 27

Purpose. To show how to can fruits and vegetables.

Directions. Send to the Division of Publications, U. S. Department of Agriculture, Washington, D.C., for *Farmers' Bulletin 839*, "Home Canning by the One-Period Cold Pack Method." Following the directions there found, demonstrate before the class the hot-water method of canning. Can at least one fruit and one vegetable.

CLEANING

Soaps. Soaps are made by the reaction of fats with substances known as alkalis. One alkali makes hard soaps; another makes soft soaps. The cleansing action of soaps is due to the fact that they unite with the fatty substances that hold the dirt, thus freeing it and allowing it to be washed away. Washing soda also acts on grease, and most washing powders are mixtures of this soda and powdered soap.

Hard water. Some waters contain in solution chemicals that interfere with the action of the soap, since the soap acts on these chemicals before uniting with the grease around the dirt. One kind of hardness, which can be overcome by boiling, is called temporary hardness. Another kind, not so easily remedied, is called permanent hardness. Enough soap must be used to act with all the chemical before the soap will have any cleansing power; and the substance thus formed is a chemical that further interferes with the cleansing. When the drinking water is hard, a supply of soft water is frequently provided in cisterns. This water may be pumped by hand, or it may be made to circulate throughout the house by means of pressure tanks, as already explained in Chapter VI.

DEMONSTRATION 28

Purpose. To learn the effect of soap on hard water.

Materials. Soap; test tubes; calcium sulphate; soft water; washing soda.

Directions. 1. To procure hard water, add calcium sulphate to some water. Shake and filter. Make a soap solution by heating a little soap in soft water in a test tube.

2. Take a little of the hard water and add to it a measured quantity of soap solution. Shake the test tube. Take the same quantity of soft water and add the same amount of soap solution as in the previous experiment. How do the results differ from those in the previous experiment? Why is hard water not satisfactory for cleansing purposes?

3. To hard water, add a little washing soda and shake the mixture. Then add some soap solution. What was the effect of the soda on the hard water?

Removing stains. A stain may usually be removed by one of the following methods: dissolving it; bleaching it; neutralizing it; or absorbing it. The following table shows what may be used to remove various stains.

KIND OF STAIN	HOW REMOVED
Grease	Dissolve in naphtha
Fresh paint	Dissolve in turpentine
Grass	Dissolve in alcohol
Iron rust	Weak hydrochloric acid for cotton or linen. Oxalic acid for silk
Mildew	Bleach with Javelle water
Lemonade	Neutralize with ammonia

Naphtha works better if placed in a bowl of warm water. Since it burns easily and, when brought near a flame, explodes dangerously, great care should be taken when using it.

CHEMISTRY OF THE KITCHEN

The chemicals used in the kitchen may be divided into three classes: acids, bases, and salts. Examples of acids are vinegar and the juices of fruits; of bases, ammonia and baking soda. An acid has a sour taste and turns blue litmus paper red, while a base has a soapy taste and turns red litmus blue. Litmus paper is used to test for acids and bases. When an acid and a base are mixed, it is possible to reach a stage in which the mixture will affect neither blue nor red litmus paper. The two substances are said to have neutralized each other. If this solution be evaporated, a new substance, called a salt, will be left. The particular kind of salt formed depends on the acid and the base used. Common salt and cream of tartar are examples of salts.

LABORATORY EXERCISE 8

Purpose. To study the chemical reaction of some substances used in the kitchen.

Materials. Red and blue litmus paper; vinegar; ammonia; limewater; lemon.

Directions. 1. Pour a little vinegar into a dish. Place in it a small strip of blue litmus paper. What change takes place? This is the test for an acid.

2. Pour a little ammonia into a dish. Place in it a small strip of red litmus paper. What change takes place? This is a test for a base.

3. Dissolve some salt in water. Put in this a piece of red and also one of blue litmus paper. Does any change occur? This is said to be a neutral substance.

4. Get as many common substances as you can from the kitchen, such as lemon, orange, limewater, sugar, sour milk, sweet milk, buttermilk, baking soda, cream of tartar, baking powder, tomatoes, an apple, any fresh fruit, tea, coffee, washing soda, soap, wood ashes, drinking water.

Test each one of these with both red and blue litmus paper. Test the juices of the fruits. Dissolve the powders in water. After letting the ashes stand, pour through a filter paper. Boil the tea and coffee in water. Place the name of each substance under one of the following headings in your notebook:

ACID	BASE	NEUTRAL

OUTLINE SUMMARY

SCIENCE OF THE KITCHEN

- I. Cooking foods
  - 1. Purposes of cooking
  - 2. Making bread light
    - *a.* Baking powder
    - *b.* Yeast
  - 3. Methods of cooking
    - *a.* Early methods
    - *b.* Fireless cooker
  - 4. Thermos bottle
  - 5. Fuels used in cooking
- II. Keeping low temperatures
  - 1. The refrigerator
  - 2. Ice cream freezer

- III. Preserving foods
  - 1. Causes of decay
  - 2. Drying
  - 3. Preservatives
  - 4. Canning
    - *a.* Killing bacteria
    - *b.* Cold pack method
    - *c.* Canning under pressure
- IV. Cleaning
  - 1. Soaps
  - 2. Hard water
  - 3. Removing stains
- V. Chemistry of the kitchen

QUESTIONS FOR CLASS DISCUSSION

1. In what ways may cooked foods be more healthful than uncooked foods?

2. How does the action of yeast differ from the action of baking powders as they are used in baking bread?

3. What are the essential differences in the various methods of cooking?

4. What advantages has the fireless cooker?

5. In what way is the construction of a refrigerator similar to that of a fireless cooker?

6. What principles involved in hot-air heating are found also in the refrigerator?

7. What are the essential differences in the various methods of preserving foods?

8. Why is hard water not satisfactory for cleansing purposes?

9. How does the method of canning corn differ from the method of canning strawberries?

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CHAPTER IX

APPLICATIONS OF ELECTRICITY

Outside of lighting, what do you consider the most valuable use that can be made of electricity in the home?

One very common use now made of electricity in the home is for lighting, as we have seen in a previous chapter. When once the electric current has been brought into the house, there are many other uses to which it can be put. The purpose of this chapter is to explain some of the applications of electricity in the home besides lighting. It can be used for cooking, for heating, and for cleaning; and electric motors may be employed to run fans and sewing machines. Some of these appliances have come into general use. The cost of other appliances and of the electricity to run them is so high that few people can afford to install them in their homes.

A recent survey shows that more than half of the 26,000,000 homes in the United States use electricity, some for lighting only, others for a wide variety of household appliances. Utah leads all the states in this respect, with 98 per cent of its homes electrified.

The use of electricity in the home is rapidly increasing. Nearly all houses that are now being built in towns and cities where electricity is available are wired for electricity. The reason for its wide use is very evident when we consider how convenient it is and how it reduces labor in the home. In a survey made in 1922 of 1,420 medium-class residences in various cities, the average number of appliances found for every hundred residences is shown in the following table:

NUMBER OF APPLIANCES PER HUNDRED RESIDENCES

APPLIANCE	NUMBER	APPLIANCE	NUMBER	APPLIANCE	NUMBER
Flatirons	80	Percolators	12	Curling irons	6
Vacuum cleaners	66	Radiators	10	Sewing machine motors	5
Toasters	30	Fans	10	Grills	4
Washing machines	28				

COOKING BY ELECTRICITY

Electricity finds many applications in cooking. Among the more common appliances are the following: electric toaster, coffee percolator, waffle iron, gridiron for cooking griddle cakes, broiler for cooking steaks, frying pan, kettle for boiling water, grills, table stoves, immersion heater for heating a small quantity of water, oven for baking, and stove for general cooking. Many of these can be used directly on the dining table at the time of the meal, such as the toaster, coffee percolator, and egg boiler. These may be connected to a special socket installed in the side wall, or to an ordinary electric lamp socket by unscrewing the bulb and inserting a plug with connecting wires attached.

Source of heat. In order that electricity may be made to produce heat in these various appliances, materials are used which have a large resistance, so as to transform the electric energy into heat within the instrument.

Wires are very commonly used; long coils of small wire are wound in a small space and placed near the object to be heated. By using different combinations of lengths and diameters, different temperatures can be obtained. A wire of nickel alloy is very frequently used; also wires of iron and German silver have been tried. In some appliances, as in the toaster, these wires are visible; in others, as in the percolator, they are covered.

Thin coatings of certain metals (such as gold and platinum) deposited on pieces of mica or some other substance may be used instead of wires. The articles coated or plated are made into the shapes which will most conveniently fit the appliances for which they are intended.

Toaster. The advantages of the electric toaster are that it can be kept on the dining table and that the toast can be kept hot. The heating element is composed of a metal ribbon, usually wound on mica and exposed to view. In some toasters the coils are placed horizontally; in others they are placed vertically.

Coffee percolator. In the electric percolator, the top portion is made on the same principle as in other percolators. At the bottom there is a heating apparatus that boils the water. This lower part is a disk stove over which the upper portion fits closely. The heating part is a long wire in the form of a spiral, fixed in enamel that is baked to the under side of the top plate. Starting with cold water, it requires about ten minutes to make the coffee. In one form of percolator, the top may be removed and the bottom part used for boiling eggs and other food.

The small disk stoves, for heating a small quantity of water for boiling eggs or for any other purpose, are made in much the same way as the bottom part of the coffee percolator.

Electric range. Electric ovens are made for baking alone. In electric ranges all kinds of cooking may be done; such a range includes an oven for baking and a series of grids for heating. Some of these ranges have automatic attachments for regulating the temperature of the ovens. In one type a clock can be set automatically to start the cooking, and the heat indicator turns off the current. Thus the housewife may set the clock for any time she wishes the cooking to start, and she may attend to other duties — go shopping if she wishes. The advantages of cooking by electricity are evident; the great disadvantages are the high cost and the longer time it takes to bring a given quantity of water to the desired temperature.

CLEANING BY ELECTRICITY

Electricity may be put to many house-cleaning uses. For this purpose we find the electric vacuum cleaner for cleaning carpets and upholstered articles, the electric washing machine and wringer for washing clothes, the iron for ironing them, and the dish-washing machine.

Electric vacuum cleaner. In the electric vacuum cleaner a motor is arranged to run a fan that sucks up the dirt through a nozzle resting on the surface that is to be cleaned. Particles of dust and dirt are picked up and collected in a bag attached to the machine. The cleaner is easily guided to any part of the room. It raises no dust and may be used to clean not only floors but also furniture, books, walls, and draperies. Electric connection may be made with any lamp socket.

Fig. 51. — Electric vacuum cleaner

Washing machine. The electric washing machine consists of a tub in which the clothes are washed, a wringer, and a motor which may be connected with either the tub or the wringer.

Electric iron. The value of the electric iron (see figure 52) is widely appreciated, and it is in general use. It maintains an even temperature; and it is especially valuable during the warm weather, as it is much more comfortable to use than the old type of iron, which requires proximity to a hot fire.

The heating part in some irons is a coil of wire wound over flat strips of mica laid close to the bottom of the iron. In other irons, the heating part consists of films of metal alloys on a mica base. Some irons have a device by means of which three degrees of heat may be obtained — high, medium, and mild. The heat is regulated by changing the position of the plug at the back, which comes in contact with three pins connected to the heating parts of the iron.

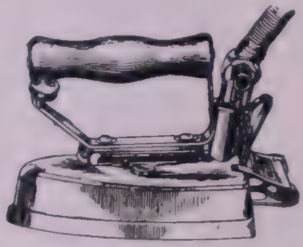

Fig. 52. — Automatic electric flatiron

Electric dish-washer. The dishes are placed in a basket on a revolving plate, and hot water is sprayed against them with such force that they are quickly cleaned. They are then rinsed in hot water and allowed to dry. The power for turning the dishes is furnished by a motor. The water may be heated either by electricity or by a fire.

HEATING BY ELECTRICITY

The electric heater may be moved from one room to another and may be used like a fireplace to take the chill off a room in the late autumn and the early spring. In the convector type of heater, the same principle is involved as in appliances for cooking. Various forms of heating parts are used. These heat the air and cause a circulation, the warm air rising and the cooler air coming near to be heated. The amount of heat may be controlled by means of switches. In another type of convector, the heating parts become red hot and give off a glow. The luminous bowl type of heater is in very wide use; this works on the principle of reflecting heat rays, directing them like a searchlight to those parts in which heat is needed.

In hospitals, electric heating pads are being used in place of hot-water bags.

The use of electricity for heating is very limited and is one of its minor uses. At the present time it cannot compete with coal, oil, and wood as a means of heating the ordinary home.

Other appliances that may be mentioned are the curling iron, the soldering iron, the vibrator for massaging, emery wheels for sharpening tools, and brushes for polishing silverware.

USES OF THE MOTOR

Motors may be used to run fans and sewing machines, to turn ice cream freezers and coffee grinders, and to work pumps.

Electric fan. The electric fan is operated by a motor. While its use in summer for cooling purposes is well known, it has other uses also. In winter it may be used to help heat the house. For this purpose it may be placed in the cold-air inlet of a hot-air furnace, or over a register, or it may be used to direct a current of air against a steam or hot-water radiator. In each case the room is heated more quickly. Fans may be used also in drying fruits and vegetables.

Sewing machine motor. A small motor may be so attached to the table of a sewing machine that it will run the machine by means of a belt. Since the stopping and starting of the motor and the control of the speed may be regulated by the knee or the foot, both hands are left free to guide the work. More work can be done, because more stitches per minute can be taken when the motor is used than when the machine is driven by the foot.

A motor may be used to operate a pump. If one has the pneumatic tank system of supplying water to the house, the motor may be attached to the pump and arranged to start and stop automatically according to the pressure in the tank.

COST OF ELECTRICITY

Since cost is one of the most practical questions to consider in the use of electricity, a few facts about cost are given in the two following tables. The first table, which is based on tests made in the department of Home Economics at the Ohio State University, shows the relative cost of cooking with different fuels at the prices that prevailed in 1917.

RELATIVE COST OF FUELS FOR COOKING

KIND OF FUEL	COST OF COOKING A DAY'S MEALS
Natural gas at $1 per 1,000 cu. ft.	5.6 cents
Soft coal at $6.50 per ton	9.7 "
Coal oil at 15 cents per gallon	13.5 "
Gasoline at 27 cents per gallon	14.5 "
Electricity at 3 cents per kilowatt hour	17.1 "

The cost of electricity for cooking for a family of five will be approximately as many dollars per month as the electricity costs in cents per kilowatt hour. For example, when electricity sells at five cents per kilowatt hour the cost for a family of five should be about five dollars per month.

The next table shows the number of watts used hourly by various appliances and the cost at the rate of ten cents per thousand watts.

COST OF RUNNING ELECTRICAL APPLIANCES

APPLIANCE	WATTS PER HOUR	COST PER HOUR (at 10 cents per 1,000 watts)
12-inch electric fan	40	2/5 cent
Vacuum cleaner	150	1½ cents
Sewing machine motor	150	1½ cents
Refrigerator	150	1½ cents (about 8 hours daily)
Washing machine (¼ H.P.)	200	2 cents
Toaster	400	4 cents
Coffee percolator	500	5 cents
6½-lb. flat iron	575	6 cents
Small hot-water boiler heater	1,500	15 cents
Electric range oven	2,500	25 cents

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In many cities a special rate of about four cents is given for cooking, in which case the last two items would fall to six cents and ten cents.

Statistics collected from 32 cities show that between the years 1913 and 1923 the cost of electricity decreased 8 per cent, notwithstanding the fact that during the same period the cost of many other commodities, such as food and clothing, had increased by 40 to 110 per cent.

ELECTRIC BELL

A device commonly found in homes is the electric bell. This illustrates the application of two electric appliances — the bell itself and the battery that operates it. When the button is pushed, the circuit is closed and the current from the battery operates the bell. When the finger is taken off the button, the circuit is broken and the bell stops ringing.

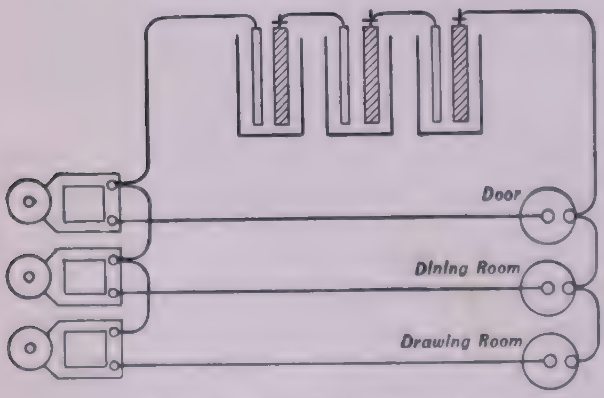

Fig. 53. — Bell circuits

Electromagnets. The most important part of a bell is a special kind of magnet called an electromagnet. Magnets may be formed in several ways. There are found in certain localities natural magnets called lodestones, which attract iron. A magnet may be made by rubbing a piece of steel with a magnet, or by bringing iron or steel under the influence of a current of electricity. If a number of coils of wire are wound around a bar of soft iron and a current of electricity is sent through the wire, the bar becomes a magnet and will pick up iron. The strength of this electromagnet may be increased by using more turns of the wire or by increasing the strength of the current.

This form of magnet is very useful because it can be controlled. If an ordinary bar magnet is brought near some iron nails, they are taken up by the magnet and adhere to it unless shaken off. If an electromagnet is brought near iron nails, they are taken up by the magnet and adhere to it only as long as the current passes through the wire. If the current is broken, the nails drop off at once. Hence the power of the electromagnet may be controlled simply by opening and closing the circuit. If the bar within the coils of wire is made of steel, this becomes a more or less permanent magnet; if a soft iron bar is used, it is magnetized only temporarily, losing its magnetism again just as soon as the magnetizing influence is removed.

How the bell works. Figure 54 indicates how the electromagnet works in the electric bell. The magnet is bent into the form of a horseshoe, *SN*. When the button *P* is pushed down and a current of electricity passes through the wire, the magnet becomes magnetized and draws down the iron bar *A*, called the armature, to which is fastened a clapper *H*. When this is drawn down, it strikes the bell. At the same time that the armature is drawn down, the electrical connection at the point *B* is broken, and hence no current passes through the electromagnet. It ceases to be a magnet and thus no longer holds down the iron bar, which is then brought back by the spring *S* to which it is attached. As soon as this happens, the contact is made again; and thus the operation is repeated.

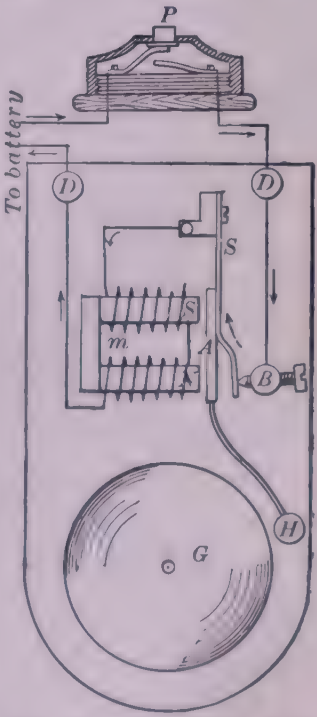

Fig. 54. — Electric bell

A small transformer is now supplanting the battery for operating door bells. It costs less to operate and is always in order.

DEMONSTRATION 29

Purpose. To study the working of an electric bell.

Since an electromagnet is an important part of the electric bell, we will first study magnets in order to understand how the bell works.

A. THE MAGNET

Apparatus. Two bar magnets; horseshoe magnet; pieces of metal (such as iron, steel, tin, zinc, a dime, a copper, a nickel); piece of glass; iron filings; darning needle.

Directions. I. *Magnetic substances.* 1. Take a magnet and try a great many substances to see which it will attract. Find the greatest distance that a piece of iron is attracted. Put the end of the magnet in a box of tacks. By trying various portions of the magnet, see which is the strongest part. Put the magnet in iron filings.

2. Test needles, pins, pens, etc., to see if they are made of iron or steel.

II. *The magnetic field.* 1. Place a bar magnet on the table and put over it a sheet of paper. Sprinkle iron filings over this paper. Make a drawing showing the way the filings arrange themselves. Put two bar magnets on the table with the north poles about an inch apart. Over these place a piece of paper and on it sprinkle the iron filings. Draw. Do the same experiment again, placing the north pole of one magnet about an inch from the south pole of the other magnet. Sprinkle filings and draw. What is the difference in the arrangement of the filings? Place a horseshoe magnet under the paper and sprinkle the filings.

III. *How to make magnets.* Rub one end of a needle on one end of a magnet, rubbing several times in the same direction. Then rub the other end of the needle on the other end of the magnet. See if the needle will pick up the tacks. The blade of a jackknife may be magnetized by rubbing over a magnet. Try bringing another needle near a pole of a magnet but not quite touching it. See if the needle becomes magnetized.

B. THE ELECTROMAGNET

Apparatus. Large nail or bolt about six inches long; about twenty feet of insulated wire; two dry cells; tacks; magnet.

Directions. 1. An electromagnet is an important part of an electric bell. It can be made as follows: Wind about ten feet of insulated wire around a large nail or bolt as thread is wound on a spool. Place the end of the nail in a pile of tacks. Is it a magnet? Connect the wire with a dry cell. Is it a magnet now? Withdraw the nail and see whether the coil will pick up fewer or more tacks. Break the connection with the cell. What happens? Connect the cell again. See if a needle can be magnetized by rubbing it against the nail.

2. Wind five feet of wire around the nail and see how the number of tacks it lifts up compares with the number when ten feet of wire was used. Try twenty feet and note the difference. Try two cells and compare with the number of tacks lifted when one cell was used with the same length of wire. In what ways shown by these experiments may the strength of an electromagnet be increased?

C. THE ELECTRIC BELL

Apparatus. Electric bell; push-button; cell.

Directions. Connect the bell and the push-button with the cell. Push on the button and notice what parts of the bell move. Make a drawing showing the connections of the bell, button, and cell. Make a careful drawing of the bell. By means of arrows show through what parts of the bell the current passes.

ELECTRIC CELLS

A very simple cell may be made by putting strips of copper and zinc, with a wire attached to each, into a weak solution of sulphuric acid. If the wires are brought together a current is formed, as may be shown by holding the wire over and parallel to the needle of a compass. The needle will be turned from its north and south position. The cause of this current is the dissolving of the zinc. The atoms of dissolved zinc are positively charged. As the action in the cell continues, the copper is covered with bubbles of hydrogen, which are poor conductors of electricity. After a while so many bubbles collect on the copper that the current cannot pass through; therefore, the cell ceases to give any current.

In order to make a cell that will be of practical use, it is necessary to find some way of preventing the accumulation of this gas on the metal. The method generally used is to put into the cell a second chemical that unites with the hydrogen before it collects on the metal. A number of different chemicals may be used. In one cell copper sulphate is used, which takes up the hydrogen and in its place gives its copper to be deposited on the copper strip. In other cells a compound is used whose oxygen unites with the hydrogen.

Classes of cells. Two types of cells are commonly distinguished — the wet and the dry. The Leclanché cell is a type of wet cell sometimes used for door bells (see figure 55). Carbon and zinc are used and placed in a solution of sal ammoniac. The carbon is placed in a porous cup and surrounded with a compound which oxidizes the hydrogen.

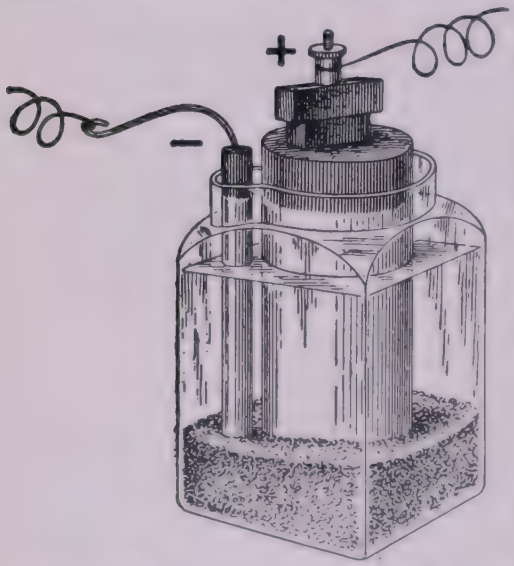

Fig. 55. — Leclanché cell

Dry cells. The dry cell (see figure 56) is now largely replacing the wet cell on account of its greater convenience for handling. It is not really a dry cell but a moist cell, as the chemicals are brought into contact in the form of a moist paste. Most of these dry cells are similar to the Leclanché cell. The elements used are carbon and zinc, and the chief chemical is sal ammoniac. The outer shell of the cell is made of zinc. Inside this is a mixture of sal ammoniac and plaster of Paris made into a stiff paste. In the center is a rod of carbon surrounded with manganese dioxide. The two chemicals are separated by blotting paper. After the cell is moistened, it is sealed with pitch to prevent the water from evaporating. If the cell really did become dry, it would be worthless.

Demonstration 30

Purpose. To learn how the cell used to operate the electric door bell is made.

Apparatus. Strip of sheet zinc and strip of sheet copper, each with a wire attached; sulphuric acid; compass; tumbler; sal ammoniac cell; dry cell sawed lengthwise into two equal parts.

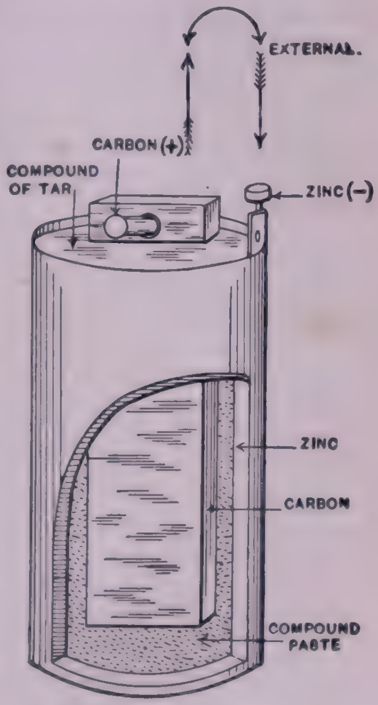

Fig. 56. — Dry cell

Directions. 1. A simple cell may be made as follows: Fill a tumbler about two thirds full of water, and add to this about one twelfth as much sulphuric acid. This should be handled with great caution. Put the strips of copper and zinc in this solution in such a way that they do not touch. Notice what takes place on the surface of each metal. Connect the two wires and see if there is any difference in what happens on the surface of the two metals. Hold the wire north and south and place a compass directly over it. What happens to the needle?

2. The sal ammoniac cell is very commonly used to operate door bells. Set up the cell, noting the different parts. Make a drawing of a longitudinal section through the cell.

3. Sometimes dry cells are used to operate the electric bells. Make a drawing of a dry cell cut in two lengthwise. Label the parts and explain the use of each part.

Home Project 7

Purpose. To study the parts of an electric door bell outfit, and to fix it if it gets out of order.

Directions. 1. If you have an electric door bell in your home, study it to see how the different parts are connected. Make a drawing showing the bell, push-button, wires, and cell. Notice the kind and number of cells. If more than one are used, show in your drawing how they are connected.

2. If your door bell is out of order, see if you can fix it. First, test the bell by connecting it directly with a battery. Then look at the cells.

They may need either a new zinc, more sal ammoniac, or simply more water to take the place of that which has evaporated. Look at the binding posts and see if the contacts are tight. Scrape all contacts to free them of nonconducting materials that may have accumulated. If the trouble is not with the cell, look at the push-button to see if the contact here is all right. Examine the bell to see if the connections with the binding-posts are secure and if the points make proper contact. Very rarely it might happen that the wire is broken somewhere.

OUTLINE SUMMARY

Uses of Electricity in the Home

I. Cooking by electricity
    1. Source of heat
    2. Toaster
    3. Coffee percolator
    4. Electric range

II. Cleaning by electricity
    1. Vacuum cleaner
    2. Washing machine
    3. Electric iron
    4. Electric dish-washer

III. Heating by electricity

IV. Uses of motor
    1. Electric fan
    2. Sewing machine motor

V. Cost of electricity

VI. Electric bell
    1. Electromagnets
    2. How the bell works

VII. Electric cells
    1. Classes
        a. Dry cells

QUESTIONS FOR CLASS DISCUSSION

1. What is the principle involved in the various instruments used for cooking by electricity?

2. What are the advantages of using electricity in the home?
3. What uses can be made of the motor in the home?
4. Explain how the electric bell works.
5. How do cells generate electricity?

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CHAPTER X

MUSICAL INSTRUMENTS

What advantages, as a source of pleasure in the home, has each of the following instruments as compared with the other two: phonograph, piano, violin?

THE PHONOGRAPH

Uses in the home. Musical instruments furnish a pleasant means of home entertainment. The phonograph is coming to be very widely used, and its advantages are evident. It does not require years of practice before one can play it, since anyone can learn in a few minutes to run the machine. Another advantage is the great variety of selections that can be played upon it, representing all kinds of musical instruments and combinations of human voices. Not only can one listen to a great variety of music, but one can hear the very best, as many of the most famous singers and musicians are having records made of their performances.

The phonograph is one of the wonders of the last twenty-five years. It opens great possibilities for the future. Records of the songs of great singers and of the speeches of great orators and famous men may be preserved to be used long after these people have died. We may get some conception of what this will mean if we suppose that today we had records of the farewell address of Washington or of the Gettysburg address of Lincoln, so that we could listen to the voices of these great men.

Other uses. Although the use of the phonograph in the home as a source of enjoyment is the most common use of it now made, the principle of the phonograph is being used for other practical purposes and will doubtless be so used even more in the future as its various applications are perfected. A few of these uses will be merely mentioned. The dictaphone is coming to be commonly used by the business man. He dictates his letters into the mouthpiece of a recording instrument, and this dictation is later copied.

In learning new languages, records may be used to obtain the correct pronunciation. Mr. Edison has recently perfected an invention by means of which a telephone conversation may be recorded on a phonographic cylinder. A phonographic clock has been devised which calls off the hours and the quarter hours.

History. The phonograph was invented by Thomas A. Edison in 1877. The first machine included a mouthpiece across which was stretched a thin membrane; to the under surface of the membrane a sharp point was attached. Just beneath this point was a cylinder covered with tinfoil, which was rotated by hand. As one spoke into the mouthpiece, the membrane with the point attached vibrated and the point made markings on the tinfoil beneath. The groove thus made varied according to the loudness of the sound. A loud sound made a relatively deep impression, while a soft sound made a shallow impression. When the record on the tinfoil was finished, the point on the membrane was set back on the first part of the groove, and the cylinder was turned by hand. As the point followed the groove, it reproduced in the membrane nearly the same vibrations that had made the indentations; and it thus reproduced the sounds that had been spoken into it. The words first

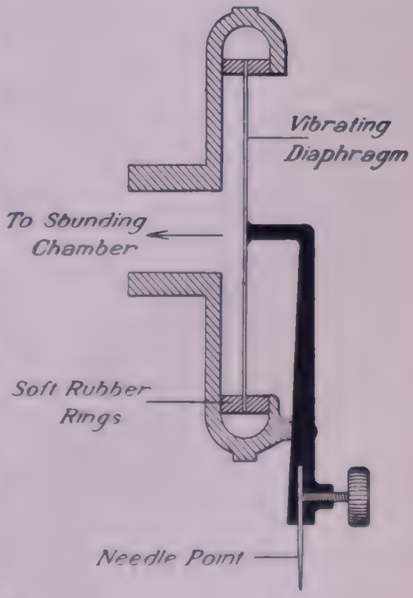

Fig. 57. — Section of a phonograph

spoken into the mouthpiece by Mr. Edison and the first reproduced by the phonograph were the lines of the poem, "Mary had a little lamb."

Recent improvements. Since that time many improvements have been made in the phonograph, but the essential principles are the same as those used in that first crude machine. In the modern phonograph the plate on which the record rests is kept rotating by means of a spring, which is wound up by a crank on the side of the machine. A uniform speed is maintained by means of a ball-type governor. The faster this governor rotates in time with the phonograph, the more the balls are thrown out; and this motion brings a disk on the axle into contact with a friction pad in such a way that the speed is lessened. The speed may be regulated by means of a screw which controls the position of the pad.

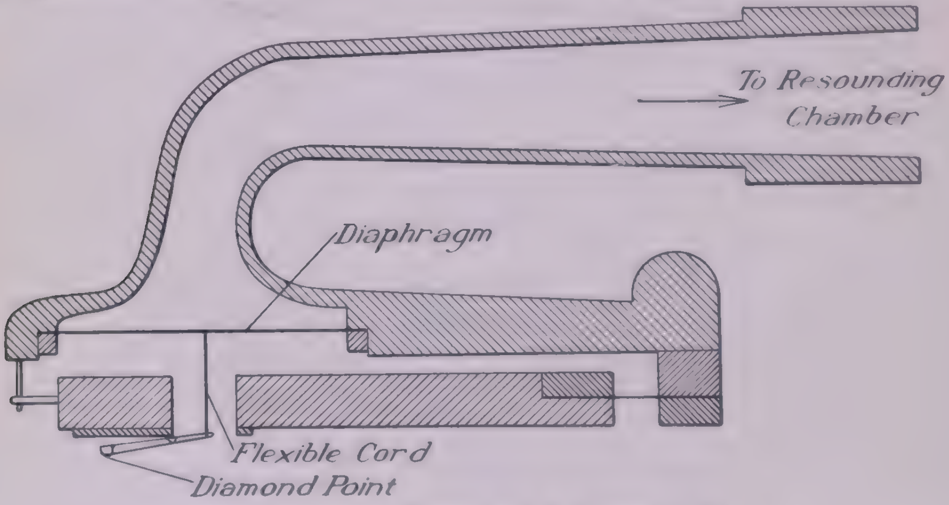

Fig. 58. — **Section of a phonograph**

The tones are strengthened by means of horns. Sometimes these are visible and attached on the outside; in the box or cabinet form, the horn is hidden by the sides of the box.

Making records. The making of records is now a large industry. Formerly two kinds of records were in use, the cylinder and the disk; now, only the disk record is used for the phonograph. The master record is made in wax; then, by electroplating, a negative is made in metal. Other secondary masters or records are made from the metal negative. The records of some machines, as the Victor, are lateral cut; that is, the needle is moved from side to side as it follows the groove. On other records, as the Pathé and the Edison, the needle moves up and down. These are called vertical cut or "hill and dale" records. One may note the difference in position of the reproducing diaphragm on the two types of machines.

In 1923 in this country 981,000 phonographs and 98,000,000 records were made.

The more common musical instruments may be divided into three groups: the stringed instruments, such as the piano and the violin, in which the sound is produced by vibrations of strings; the wind instruments, such as the cornet and the flute, in which the sound is produced by vibrations of columns of air; and the percussion instruments, in which the sound is produced by vibrations of a membrane or of metal disks, such as the drum and the cymbals.

STRINGED INSTRUMENTS

There are three types of stringed instruments: first, those in which the strings are set in motion by hammers, as in the piano; second, those in which the strings are set in vibration by bowing, as in the violin; and third, those in which the strings are set in vibration by the fingers, as in the guitar.

The piano. *History.* The first crude piano was made in the year 1711 by an Italian. This has gradually been improved upon till we have the wonderful instrument of today. The first piano was square, but today we have the grand and the upright, the latter being the type in most common use in the home. Another improvement introduced about the same time as the upright was the overstrung piano, with the bass strings obliquely across and over all the other strings. The reason for the overstrung piano is to equalize the tension. If all strings were of the same length and weight, the variation in tension between the strings giving high pitch and those giving low pitch would be very great.

Construction. The essential sound-producing portion of the piano consists of three parts: the strings, whose vibrations produce the sound; the mechanism for setting the strings in vibration; and the sounding board (see figure 59). The purpose of the sounding board is to increase the volume of the sound. The volume of sound given out by the wires alone would be too small to make the instrument satisfactory.

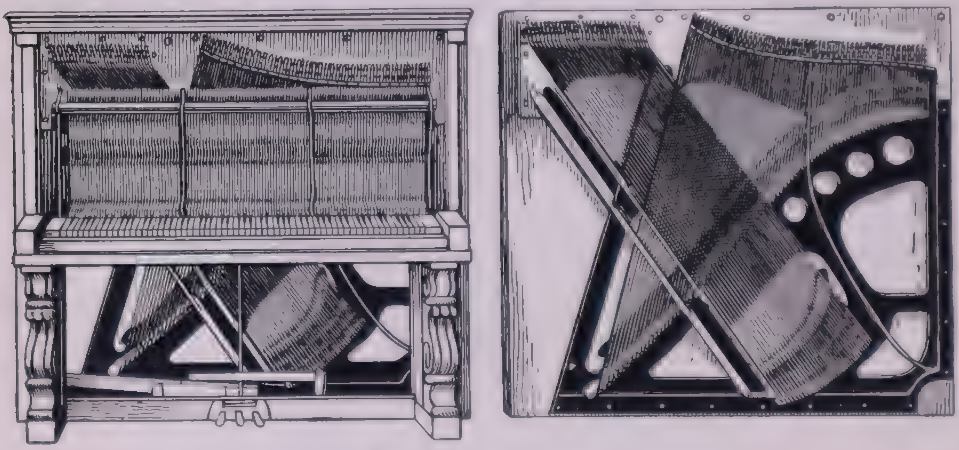
Fig. 59. — Piano

The mechanism which sets the strings in vibration is a system of levers so arranged that when a key is pressed down a hammer strikes the wire. Usually several wires are struck for each note. As soon as the strings are struck, a damper falls on them to check their vibration so as not to interfere with the succeeding notes of other strings. The action is so rapid that the hammer falls back instantly, ready to be struck again. The action is very complicated. In the action of a single key and hammer in an upright piano there are concerned nearly a hundred separate pieces of various materials.

Pedals. Pressing the loud pedal lifts the dampers away from the strings so that the tone is more prolonged. In some pianos the soft pedal pushes the row of hammers nearer to the strings, thus reducing the force of the blow. In other pianos the pedal shifts the whole mechanism so that fewer of the strings under one hammer are struck.

Quality of tone. The quality of tone given out by a string is affected by the place where the hammer strikes it. While the string is vibrating as a whole, it is at the same time vibrating in parts — in halves, thirds, fourths, etc. Each of these vibrations gives out a certain tone called an overtone, and these all combine to give the note characteristic of a certain string. A large number of these overtones is desirable, as they help to make a more pleasing sound. The overtones given off are affected to some extent by the place where the string is struck, as certain desirable overtones may be destroyed if the string is struck at a particular place. In order to allow these desirable overtones to appear and to eliminate the objectionable ones, it has been found best to have the hammer strike the string at a distance from the end of the wire of from one seventh to one ninth of its length.

Pitch of tone. The pitch of a tone depends on the following factors: (1) length of string, (2) mass of string, and (3) tension. Short strings, light strings, and strings under high tension tend to produce notes of high pitch. Long strings, heavy strings, and strings under a small tension tend to produce notes of low pitch.

The piano is constructed with strings varying in length and size. The bass strings are made of steel wound with copper and steel. This weighting lowers the pitch. The piano is finally tuned by varying the tension through turning the tuning pins.

Other stringed instruments. In the violin the vibration is produced by a bow instead of a hammer. The pitch of the strings in the first place is controlled by means of size, materials, and tension; and the violin is tuned by changing the tension through turning the keys. After the violin is once tuned, the pitch of the various notes is controlled through varying the length of the strings by pressing them against the board with the fingers.

The method of controlling the pitch of the notes in the guitar and the banjo is similar to that in the violin. The strings are set in vibration by the fingers instead of the bow, and the sounding board of the banjo is made of membrane instead of wood.

DEMONSTRATION 31

Purpose. To study some of the principles underlying the action of musical instruments.

Apparatus. Tuning fork; sonometer; violin or guitar.

Directions. 1. Set a tuning fork in vibration. Hold it firmly on the box of a violin or guitar, or on any ordinary box. What difference is there in the sound? What is the use of sounding boards?

2. Fasten on the sonometer two strings of the same material but different in diameter. Bring the two to equal tension. Strike them both and note the difference in pitch.

3. Fasten two strings of the same size and under the same tension but of different materials. Strike them and note the difference in pitch.

4. Use two strings of the same size and material. Put one under greater tension than the other. How do they differ in pitch? Fasten two strings of the same size and material under the same tension, but have one wire about twice as long as the other. How do they differ in pitch?

5. Upon what factors, as indicated by these experiments, does the pitch of a string depend?

WIND INSTRUMENTS

In wind instruments the sound is produced by the vibration of air columns. The air may be set in vibration in several ways. In the flute it is set in vibration by blowing across a hole; in the clarinet, by means of a vibrating reed; and in the cornet, by means of the vibrating lips of the musician. The pitch is controlled in a variety of ways: by changing the length of the vibrating air column, as in the pipe organ; by blowing gently or hard, as in the clarinet; or by a combination of several means, as in the flute.

OUTLINE SUMMARY

Musical Instruments

I. The phonograph
    1. Uses in the home
    2. Other uses
    3. History
    4. Recent improvements
    5. Making records

II. Stringed instruments
    1. Piano
        a. History
        b. Construction
        c. Quality of tone
        d. Pitch of tone
    2. Other stringed instruments

III. Wind instruments

QUESTIONS FOR CLASS DISCUSSION

1. What is the most valuable use made of the phonograph?

2. What circumstances might make the phonograph a more desirable instrument than the piano to have in the home?

3. If phonographs had been in use for a long time, so that records made fifty or a hundred years ago could be obtained now, of what use would they be to us?

4. How is the phonograph able to reproduce the human voice?

5. How is the pitch of the tones determined and controlled in each of the following instruments: piano, violin, guitar, and the various wind instruments?

6. How do stringed instruments differ in the methods by which the strings are set in motion?

7. How do wind instruments differ in the ways by which the air is set in vibration?

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CHAPTER XI

TAKING PICTURES

1. What must one know about a camera in order to take good pictures?

2. What are the different ways in which films may be developed and prints made?

HISTORY OF PHOTOGRAPHY

The process of taking pictures is now a very simple matter, and anyone who wishes may easily learn to take them. But it has not long been so simple. Like other applications of science, photography has gone through many changes, starting from crude beginnings and improving till it has reached its present state of development. Before photography was possible, two inventions or discoveries were necessary: first, the discovery that certain salts are affected by sunlight; and second, the invention of a device by which rays of light from an object could be focused to form an image.

The first photograph was made about 1800; but the man who made it was not able to keep the picture after it was taken, because the sun blackened it. About twenty years later a liquid was discovered which made permanent the image formed on the sensitive salts by exposure to light. The first real portraits from life were made about 1840, the picture being taken on a metal plate. A few years later glass was used.

The first pictures on glass negatives were taken by the wet plate process, in which it was necessary to have the plate wet while it was being exposed in the camera. About 1850 the invention of the dry plate marked a great advance in photography. The next great improvement was the use of films in place of glass for the negatives. Meanwhile great improvements were made also in the construction of the camera.

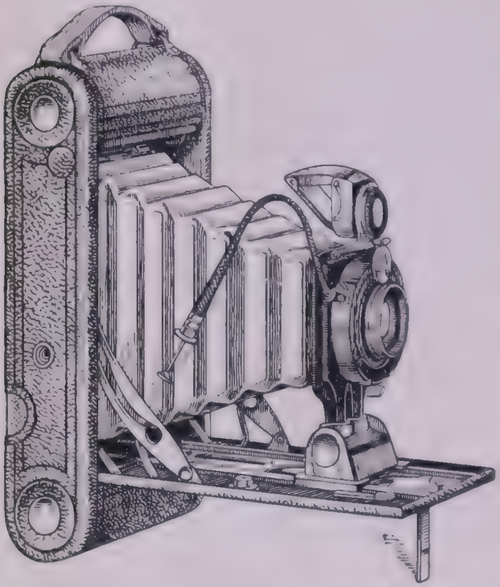

Fig. 60. — Folding camera

THE CAMERA

Parts. An ordinary focusing kodak (see figures 60 and 61) consists of the following parts: A *lightproof box*, which may be drawn out in the form of a bellows, has in the front end a *lens* which focuses an image on a film or plate placed at the back of the box. Near the lens are the *diaphragm*, having at its center an adjustable opening through which the light passes, and the *shutter* by means of which the exposure is made. On the front of the camera is a *finder* by means of which those objects that will appear in the picture may be seen.

DEMONSTRATION 32

Purpose. To show how a camera forms images.

Apparatus. Convex lens; cardboard; camera.

Directions. 1. Hold a piece of cardboard on the side of a convex lens away from a window. Move the cardboard back and forth until a distinct image of the window is formed on it. How does the image differ from the object?

2. Take a camera apart and notice the use of each part in taking a picture.

Loading the camera. Cameras may be loaded in three ways: with glass plates, with a roll of film, or with a film pack. If plates are used, the loading is done in a dark room. As ordinarily used, the film is done up in rolls having from four to twelve exposures. This film may be loaded in the daylight. It is mounted on a spool, which is attached to one side of the camera. It is then unrolled and passed around the back of the camera to a spool on the other side. The camera is then closed and the spool is turned by means of a key on the outside of the camera till the figure 1 on the back of the film is seen through a little window of red glass on the back of the camera.

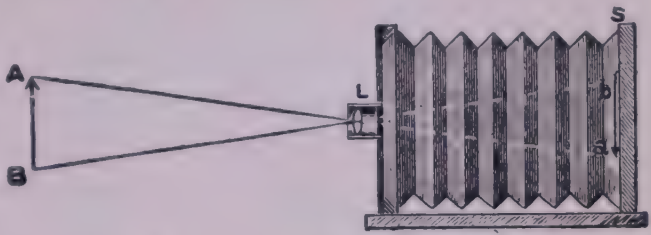

Fig. 61. — Principle of camera

MAKING THE EXPOSURE

Three things need to be considered in making the exposure: first, focusing the camera; second, the size of the "stop" or lens aperture to be used; and third, the time of the exposure.

Focusing. Two methods of focusing are used: by throwing the image on a ground glass, and by judging the distance of the object and setting the lens of the camera to correspond. In the first method a piece of ground glass is set in the back of the camera in the position to be occupied by the plate on which the picture is to be taken. The camera is pointed at the object, the shutter is opened, and a door at the back is opened to expose the focusing glass. The operator throws a cloth over his head to exclude the light, or, in the case of a hood camera, uses a folding hood, and by looking at the image on the glass determines when the object is in focus. Meanwhile he moves the lens or the back of the camera back and forth by means of a thumbscrew, till the image on the glass shows distinctly. This image is inverted, except in the reflecting type of camera.

In the other method of focusing, the camera is tested before leaving the factory, and the positions at which an object will be in focus for certain distances are marked on the camera. The photographer estimates the distance of the object and sets the lens accordingly. When this method of focusing is used, there is attached to the camera a finder, in which appear the objects that will show in the picture. In the box type of camera, there is no focusing arrangement, as the camera is so made that any object, within ordinary limits, will be fairly well focused.

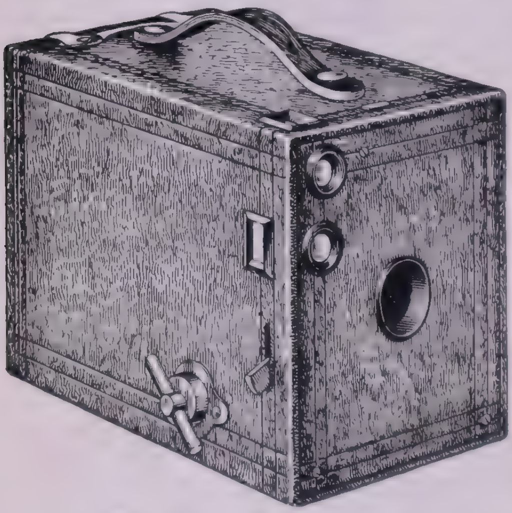
Fig. 62. — Box camera

Setting the diaphragm. The diaphragm is used to regulate the amount of light that passes through the lens. The use of a small hole tends to give better definition to the picture. The size to be used depends on several factors. On a dark, cloudy day a larger hole is used than on a bright, sunny day. A larger hole is needed for a snap shot than for a time exposure.

Setting the shutter. The shutter is a delicate piece of apparatus, which can be set for a number of combinations. For example, in one common form, there are found at the top the capital letters *B* and *T* and the figures *25* and *50*. If the pointer is set at *B*, the shutter remains open as long as the finger is held on the lever; the shutter closes when the finger is removed. If the pointer is set at *T*, the shutter opens when the lever is pressed down, and stays open till the lever is pressed down again. When set at *25*, an exposure of $\frac{1}{25}$ of a second is given, and at *50*, an exposure of $\frac{1}{50}$ of a second. The shutter may be worked by a lever or by compressed air from a bulb.

The time of exposure depends on a number of factors, such as the following: kind of day, time of day, time of year, nature of object, location of object, and size of stop in diaphragm. The following table shows how the time of exposure is affected by these various factors. The conditions in the left-hand column require longer time than the corresponding conditions in the right-hand column.

Longer Time	Shorter Time
1. Cloudy day	1. Sunny day
2. Early forenoon and late afternoon	2. Midday
3. Winter	3. Summer
4. Small stop	4. Large stop
5. Indoors	5. Outdoors

Anything that causes a change in the brightness of the light affects the time of exposure. The stronger the light that enters the camera, the less the time needed. The time varies from a small fraction of a second to several seconds. Exposure tables may be secured which give the proper time for different combinations. For interior scenes much more time is needed than for outdoor scenes.

For making snap shots the camera may be held in the hand. For making time exposures the camera must be placed on some solid support, such as a tripod, in order to keep it steady.

Flashlights. By means of flashlight powders, it is possible to obtain pictures at night which are nearly as good as those obtained in the day. The flash powders are now sold in the form of sheets, which can be easily lighted. The sheet is pinned to a piece of cardboard and should be placed two or three feet behind the camera and two or three feet to one side. It should be placed at the same height as the camera, or a little higher. Just before the picture is to be taken, the shutter is opened, the largest stop being in position, and then the flash paper is lighted; after the flash the shutter is closed at once. The time occupied by the sheet in burning is about one second.

DEMONSTRATION 33

Purpose. To show how to use a camera.

Directions. To show the various steps in taking a picture, take a group picture of the class indoors, explaining the things that must be done in focusing the camera, setting the stop, and making the exposure.

DEVELOPING

Effect of light on film. After the film is exposed, if it is taken into a dark room and examined by a red light, it will be found to look just the same as before exposure. The changes that have occurred are not of such a kind that they can be seen with the eye. Nevertheless, there have been chemical changes produced by the light that struck the film. We are familiar with the fact that light produces changes in some substances. When some kinds of cloth are exposed to light, they fade. Likewise some wall papers fade after a few years, as do carpets and rugs. Even an ordinary newspaper changes color when exposed to light for a long time.

Some substances are much more sensitive to light than others. Compounds of silver with the elements iodine and bromine are very sensitive to light, and photography is based on this property of these compounds. The film or glass plate on which the picture is to be taken is covered with a thin coating of gelatin with which these compounds are mixed. When these are exposed to light, chemical changes take place, the amount of change depending on the brightness of the light. A white object will produce more effect on the plate than a black object; and thus, by this difference in the action of light from different objects, changes are produced which can later be made visible and reproduced as a picture.

DEMONSTRATION 34

Purpose. To show the effect of light on certain salts of silver.

Materials. Silver nitrate, sodium chloride, and potassium bromide.

Directions. Dissolve a little silver nitrate in water in a test tube. Add an equal quantity of a solution of sodium chloride. Filter, and expose the filter paper to sunlight. What change takes place? Repeat the experiment, using potassium bromide in place of sodium chloride.

The developing solution. In order to make these changes in the film visible, the film is treated with a chemical called a developer. This developer acts on the film in such a way that metallic silver is deposited in those portions of the film that have been acted on by the light. In those parts that have been most acted upon, the largest amount of silver is deposited; and in those parts in which there has been the least action, the least silver is deposited. Light objects, therefore, appear in the negative as very dark, because there is the most silver; dark objects appear as very light, because there is the least silver. The plate or film at this stage is called a negative, because the lights and shadows are reversed.

The fixing solution. If the developed negative were taken out into the light, the silver salts which had not been acted upon would be affected by the light, and the negative would be spoiled. Hence the negative is placed in a solution of hypo, which is called the fixing solution. This dissolves the silver salts which have not been acted on. That which remains on the plate is permanent, and it may now be taken into the light.

Developing in dark room. There are two methods of developing — the dark-room method and the tank method, which can be carried on in daylight. In the dark room all ordinary light must be excluded; but since it is found that red light has very little effect on the plates, a red light is provided by means of which the work can be done. The developers are most easily bought in the form of powders. These are dissolved in water and poured into a tray. Two other trays, one with water and one with hypo, are provided.

The plate is first placed in water in one of the trays and then put in the tray containing the developer. In a short time lights and shadows begin to appear, and then the outline of the objects. The stage of development may be watched by holding the plate up to the red light. Only experience can tell one when to stop the development. The plate is then placed in water to remove the excess of developer. Then it is placed in hypo, where it is allowed to stay for about fifteen minutes, till the salts that have not been affected by the light are dissolved. The plate is then washed for about an hour in running water, or it may be left to soak for five minutes in each of several changes of water. It is then taken out and dried.

Films may be developed in the same way. They may be cut and the parts developed separately, or the whole film may be developed at one time.

The glass plates may be developed also in a tank in which a number of plates can be placed at once. While in the dark room, the developer is poured into the tank and the plates are put in. If the tank is provided with a light-tight cover, the rest of the work may be done in the daylight. The plates are allowed to remain a certain length of time, depending on the strength of the solution and its temperature. When the necessary time has elapsed, the developer is poured out, the plates are washed with water, and the hypo is added. In this process one does not look at the plates at all while developing. In tank development a weaker solution is used than in dark-room development, and hence a longer time is required.

Kodak film tank. Films may be developed without a dark room by using a kodak film tank. This consists of a light-tight box within which the film is wound up in an apron. The reel is then taken out and put in a receptacle containing the developing solution. It is kept here a certain time, depending on the strength and the temperature of the developer. It is then taken out and the film is put in the fixing solution. Finally the film is washed and dried.

PRINTING AND MOUNTING

The lights and the shadows are reversed in the negative; but when a print is made from this, we get the lights and the shadows in their true relations. The printing paper contains salts of silver, like the dry plate or film, only they are not so sensitive to light. This paper is put in contact with the negative and exposed to light. Where shadows are heaviest on the negative, the least light will pass through, and so under this the print will be light; while those parts of the negative that are lightest will allow the most light to pass through, and here the print will be dark. Thus the conditions in the object from which the negative was made are reproduced.

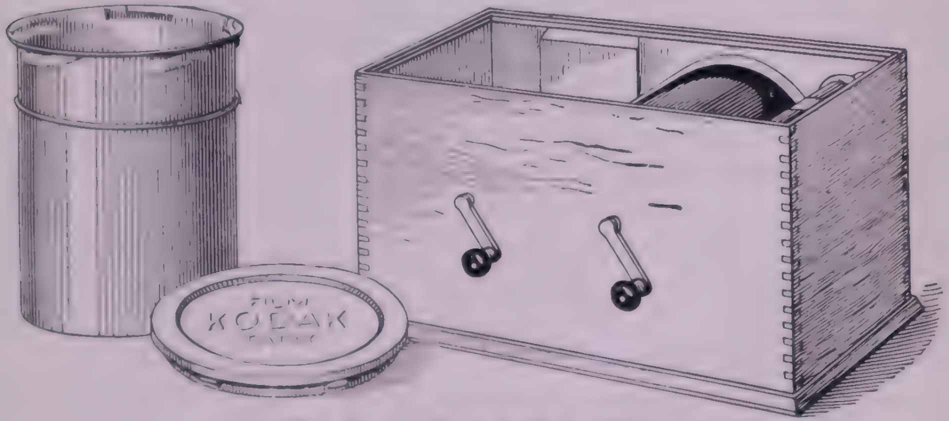

Fig. 63. — Kodak film tank

The paper is placed in contact with the negative and exposed to some light, such as gas or electricity. The time depends on the kind of paper, the light used, and the distance the paper is held from the light. For holding the negative and the paper, a printing frame is used. The paper should be handled in a room with subdued light and brought near the source of light only at the time of exposure. The treatment of this paper is much like that of the exposed film. After exposure the paper is placed in a developing solution till the printing has reached the desired stage; then it is dipped in water and placed in hypo, as was done while making the negative. The paper is then placed in running water for a time, or in five or six changes of water, and is finally taken out and dried.

The prints may be mounted by using a dry mounting tissue, which comes in thin sheets and may be applied by pressing with a hot iron; or the prints may be soaked in water and then mounted by using starch paste.

DEMONSTRATION 35

Purpose. To show how to print pictures.

Apparatus. Developed films; printing frame; some developing paper and the necessary chemicals for using it.

Directions. 1. Make a print from a film, using a developing paper and following the directions that come with it. Use one of the slow printing papers. This may be done in the daytime in the schoolroom, if the curtains are pulled down and if the paper is put into the frame in a drawer or closet that is partly darkened.

2. Pupils who have cameras may be invited to bring films and to print pictures for themselves.

3. The method of mounting prints may be shown also.

OUTLINE SUMMARY

TAKING PICTURES

I. History of photography
II. The camera
    1. Parts
    2. Loading the camera
III. Making the exposure
    1. Focusing
    2. Setting the diaphragm
    3. Setting the shutter
    4. Flashlights

IV. Developing
    1. Effect of light on film
    2. The developing solution
    3. The fixing solution
    4. Developing in dark room
    5. Developing in kodak film tank

V. Printing and mounting

QUESTIONS FOR CLASS DISCUSSION

1. In what ways is the camera similar to the eye?

2. How does the process of taking pictures used today differ from that used fifty years ago?

3. What advantages has the film over the glass plate?

4. What kind of camera would you prefer to have?

5. Which is the better of the two methods of focusing?

6. On what does the time of exposure depend?

7. Which is the better method of developing, the dark-room method or the tank method?

8. What effect does the developer have on the plate or film?

9. Why must a fixing solution be used?

10. In what ways is the treatment of a developing paper like the treatment of a film?

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CHAPTER XII

RAISING HOUSE PLANTS

What plants are suitable for growing in the house, and what care do they require?

Equipment

Window boxes and pots. The receptacles used in raising house plants may be either flowerpots or window boxes. If flowerpots are used, the smaller sizes should be avoided, as they dry out quickly. The five- and six-inch pots are the most convenient sizes. Very satisfactory window boxes of a size to suit conditions can be made out of boards. Holes should be bored

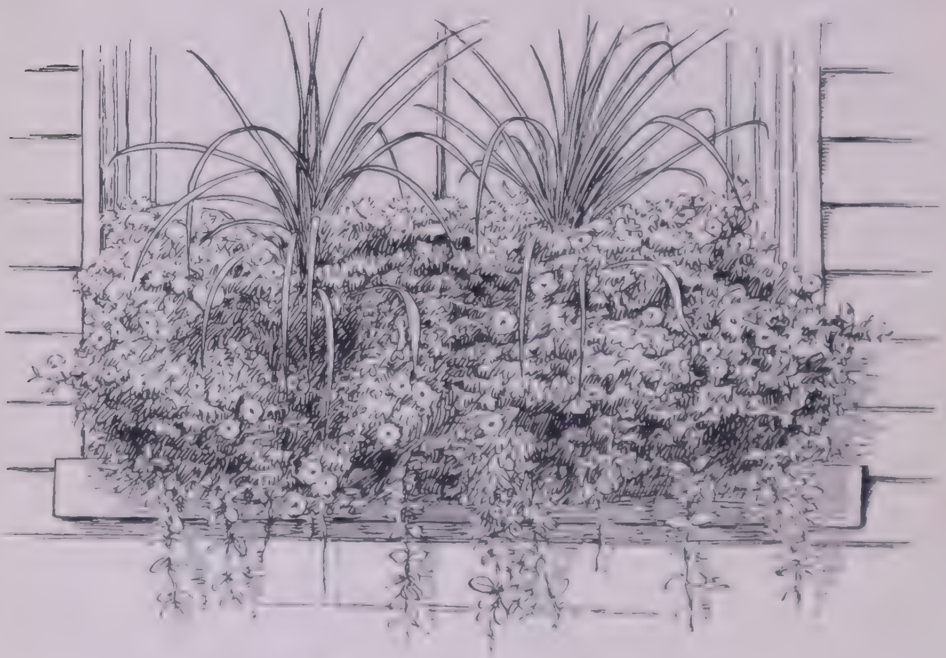


Fig. 64. — A window box

in the bottom to allow the excess of water to escape, which may be collected in a zinc tray placed beneath the box. Before the soil is put into the receptacles, pebbles or other coarse material should be placed in the bottom to provide good drainage.

There is a "self-watering flower box" which is made entirely of metal and has a double bottom. In the upper bottom are two holes. In one of these is fitted a sponge, and in the other is a tube that leads to the top of the box. Through this tube water is poured into the bottom of the receptacle; the water is then drawn up by the sponge and passed on to the soil through capillary action. In this way one watering insures that the soil will be kept moist for several days. The various receptacles may stand on a table or plant stand in front of the window, or they may be placed on the sill or on shelves or brackets in the window.

PLANTS TO SELECT

General suggestions. In deciding on which plants to select, one should first note the conditions of light in the room in which the plants are to be kept — whether it is sunny or shaded during most of the day. If the room is sunny, a great variety of plants may be grown; but if it is shaded, care must be taken to select plants that do well in such situations. Ferns are among the best plants for shaded rooms; other plants that will thrive fairly well in the shade are asparagus sprengeri, aspidistra, begonia, English ivy, oxalis, and primroses. These will also do well in the sun.

Others that are well adapted for a sunny location are geraniums, heliotropes, Wandering Jew, Fuchsia, and bulbous plants. In general it may be said that the plants that thrive best in the shade are those that are raised for their foliage rather than for their flowers.

Illuminating gas interferes with the growth of plants; if this is used in the house, the kinds of plants that can be successfully raised will be limited.

Bulbs for indoor blooming. Flowers can be easily obtained in the winter by planting bulbs in the fall. Roots are formed in some cool, dark place, and the plants are then brought into

Fig. 65. — Window made attractive with house plants

the house; and by means of warmth and watering they are forced to bloom earlier than they would have done if left outdoors until the warmth of spring started their growth.

Equipment needed. Ordinary flowerpots may be used for holding the bulbs, or a shallow wooden box with holes for drainage may be made. Over the hole in the bottom of the pot should be placed a flat stone or piece of broken pot, and on this a few more pieces of coarse material to allow good drainage. On this a little soil should be placed, and then the bulb, which is covered with enough soil to just conceal the tip.

Care of the bulbs. The pots should then be set in a *dark, cool* place and allowed to remain until the root systems of the bulbs are well developed. If there is a part of the cellar not affected by the furnace heat, the pots may be placed there and covered to keep out the light. They should be watered occasionally. The bulbs may be set away at any time from the middle of September until the middle of November; but in general, October is the best time.

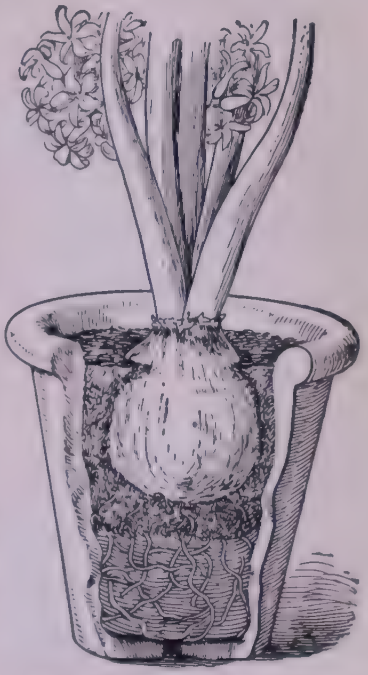


Fig. 66. — Hyacinth bulb that formed roots while it was in the dark

The first three bulbs named in the table on page 184 will not stand freezing and so must be kept at a temperature above thirty-two degrees. The other bulbs will stand a temperature below freezing.

When the plants are first brought in, they should be kept for a few days in dim light and at a low temperature and then gradually brought into the bright light and high temperature of the living room. In order to secure a continuous succession of bloom, different varieties of bulbs may be chosen, or the same variety may be brought in at different times. The plants should be kept well watered.

In the following table are given some results of actual experience with a few kinds of bulbs:

NAME	TIME TO KEEP IN DARK	TIME TO BLOOM AFTER BROUGHT TO LIGHT	TIME REMAINING IN BLOOM
Chinese lily	2 weeks	5–6 weeks	3 weeks
Paper White narcissus	5–6 “	5–6 “	3–4 “
White Roman hyacinth	7–8 “	3–4 “	3–4 “
Double Roman narcissus	8–9 “	4 “	2 “
Grand Soleil d'Or narcissus	8–9 “	6–7 “	3 “
Crocus	10 “	6–7 “	4–5 “
Dutch hyacinth	10–11 “	6–7 “	2 “
Von Sion narcissus	11–13 “	4–5 “	2–3 “
Trumpet Princeps narcissus	15 “	4–5 “	2 “
Princess Marianne tulip	15–17 “	3–4 “	3 “

Growing bulbs in water. The Chinese lily, the Paper White narcissus, and the Roman hyacinth may be raised in water. Special glasses are sold for this purpose. The water should just touch the bottom of the bulb. The glass should be set away in a dark, moderately warm place until the roots develop, at which time it may be brought into the light (see figure 67).

These same bulbs may also be grown in a dish containing pebbles and water. The Chinese lily blooms very successfully when treated in this way. A shallow dish is half filled with pebbles, and the bulb is placed among the pebbles so that it will be partially supported by them. Water is added till it touches the bottom of the bulb. The dish is kept in a dark closet for a week or two, till the roots of the bulb begin to form, and is then brought to the light. Enough water should occasionally be added to keep the base of the bulb wet.

SCHOOL PROJECT 1

Purpose. To supply the rooms in the school with flowers during the winter.

Materials. Flowerpots; bulbs.

Directions. 1. The planning for providing the various schoolrooms with flowers during the winter should begin in the early fall. If a good supply of bulbs cannot be secured in town, send to some reliable firm for a catalogue. Plans should be made regarding the kinds and the number of bulbs to plant. The Chinese lily bulb should be started as early as it can be obtained in the fall, so as to secure the bloom before the Christmas

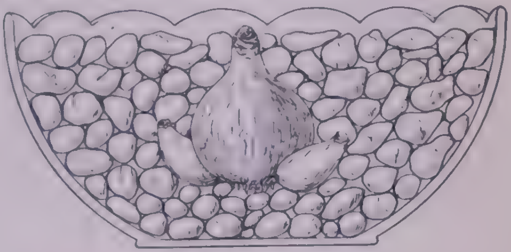


Fig. 68. — Section of a dish, showing method of planting bulb of Chinese lily

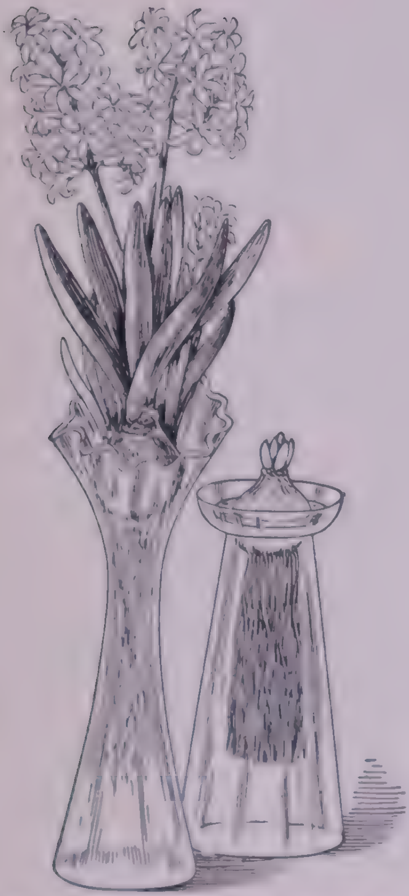


Fig. 67. — Roman hyacinth

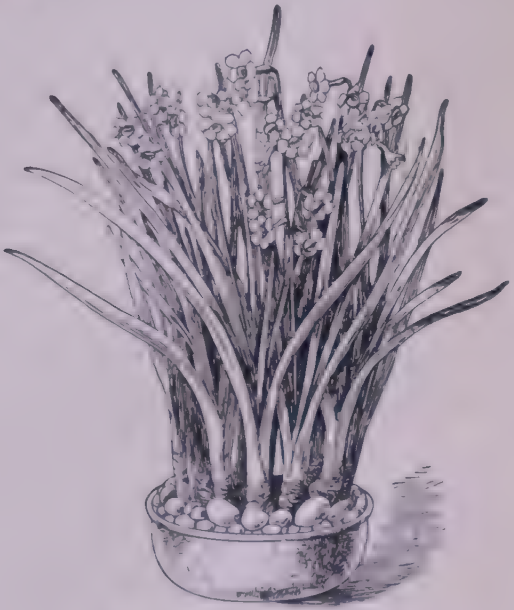


Fig. 69. — Chinese lily

vacation. The other bulbs may be brought in just after the Christmas vacation.

2. Follow the instructions already given in the text in caring for the bulbs. Special care should be taken to see that the plants do not freeze between Friday and Monday. The responsibility for doing the work may be divided among the different members of the class.

3. The particular purpose for which the flowers are to be raised may be changed to adapt it to local conditions. In some cases, flowers might be raised for the hospitals.

HOME PROJECT 8

Purpose. To raise a Chinese lily for a Christmas present.

Materials. Shallow glass dish; pebbles; Chinese lily bulb.

Directions. A novel and very pleasing Christmas present may be made for a friend by starting a Chinese lily bulb about six weeks before Christmas. At Christmas it will be just about ready to blossom. Follow the instructions given in this chapter on page 184.

CARE OF HOUSE PLANTS

Watering. The chief consideration in the care of these plants is to supply them with the right amount of water. The soil should not be allowed to become dry, nor on the other hand should it be saturated. One can tell by the appearance of the soil and by its feel to the fingers when it is dry enough to need watering. When the plant is watered the work should be done thoroughly, until water runs into the drainage pan or saucer. The water that collects in the pan or saucer should be thrown away. No more water should be given until the soil becomes dry on top.

During the cold weather, care should be taken that the plants are not exposed to a low temperature.

As the roots live in such a small amount of soil, some fertilizer should be added occasionally. Different kinds may be bought that are specially designed for house plants.

Insect enemies. The more common insects that may occasionally attack house plants are plant lice, mealy bugs, and scale insects. Plant lice, both the green and the brown species, are the most common pests. One remedy is to sprinkle tobacco dust on the leaves while they are moist, allow it to remain a few days, and then wash it off. The mealy bugs appear as tiny tufts of cotton on the leaves. Both plant lice and mealy bugs may be removed with a stiff brush, or the plant may be washed with a solution of whale-oil soap or sprayed with kerosene emulsion. The red spider is a very small animal found with its web on the under side of the leaf. It may be removed by spraying with water under pressure. If the plant is laid on its side on the basement floor or in the kitchen sink, the spray is much more effective.

HOME PROJECT 9

Purpose. To beautify the home by means of house plants.

Directions. Talk the matter over with your parents and, if they are willing and the conditions are favorable, start some house plants in your own home. Follow the directions given in this chapter.

SCHOOL PROJECT 2

Purpose. To make the schoolroom attractive by means of house plants.

Materials. Flowerpots; window boxes; house plants.

Directions. Early in the fall the class should make plans to keep some house plants in the schoolroom during the year. The boys can make the window boxes, or flowerpots may be used. Doubtless plants will be given by various members of the class; or if they are not, the class may plan some method for securing the needed plants. Some bulbs should be started as already explained in this chapter. The class may be divided into committees, each to look after the plants for a certain period.

PROPAGATION OF HOUSE PLANTS

A number of house plants may be raised by means of *softwood cuttings*, which are made from the growing parts of the stem. If only a few cuttings are to be planted, an ordinary flowerpot may be used. If a larger number is desired, one will need a box three or four inches in depth and as long as may be necessary. The receptacle should be half filled with clean, moist sand, well pressed down.

To make the cutting, a growing tip two to four inches long is cut off with a sharp knife just below a joint. The lower leaves are removed so as to make at least an inch of the stem free from leaves; to reduce the leaf surface still more, it is well to cut off about half of each of the remaining leaves. A hole is made in the sand by means of a knife, and into this the cutting is inserted for about an inch; the sand is then pressed firmly about it.

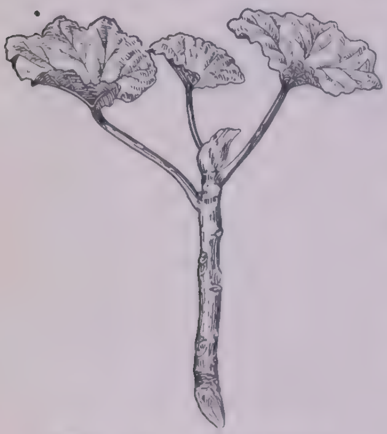


Fig. 70. — Geranium cutting

To lessen evaporation, a tumbler or a pane of glass is used as a cover, with a little crack left under the cover for the entrance of air. The sand should be kept moderately moist but not soaked. The cutting should be left until new leaves begin to form, which with a hardy plant like a geranium will take about three weeks. These leaves are evidence that new roots have formed, and the plant may now be transplanted.

Geraniums and Wandering Jew may be easily raised in this way, and also begonia, carnation, chrysanthemum, coleus, rose, and Fuchsia. Cuttings of the Wandering Jew and of some geraniums may be successfully started in water and may be transplanted after the roots have formed. However, caution must be exercised in transplanting cuttings that have formed their roots in this way, as better roots are formed in the soil than in water.

OUTLINE SUMMARY

Raising House Plants

- I. Equipment
    - 1. Window boxes and pots
- II. Plants to select
    - 1. General suggestions
    - 2. Bulbs for indoor blooming
        - *a.* Equipment needed
        - *b.* Care of bulbs
        - *c.* Growing bulbs in water
- III. Care of house plants
    - 1. Watering
    - 2. Insect enemies
- IV. Propagation of house plants

QUESTIONS FOR CLASS DISCUSSION

1. What things must be taken into consideration in selecting plants suitable for growing in the house?

2. What are some of the difficulties to be met in raising house plants?

3. What are the advantages of propagating house plants from cuttings?

4. What advantages do bulbs have as a means of obtaining flowers?

5. Of how many places can you think where the proper conditions for keeping bulbs exist?

REFERENCES

Bailey, *Manual of Gardening.* The Macmillan Co., New York.
Barnes, *House Plants.* Doubleday, Page, and Co., New York.
Rexford, *Indoor Gardening.* J. B. Lippincott Co., Philadelphia.

CHAPTER XIII

PLANTING THE HOME GROUNDS

What steps should be taken in order to beautify the home grounds?

REASONS FOR GARDENING

A large amount of pleasurable and profitable work in growing plants is possible in the home grounds by a little careful planning. Even in the small city lot, with only its back yard available, a great deal can be done; while as the size of the yard increases, the possibilities increase accordingly. The flower garden may serve to beautify the grounds; the vegetable and fruit gardens will furnish foods of the best kind at low cost; both give opportunity for healthful outdoor exercise and are a source of pleasure to the one who cares for them and watches their development through the seasons. If one has a large yard, the vegetable and fruit gardens may yield some financial return in addition to keeping the home table supplied with vegetables.

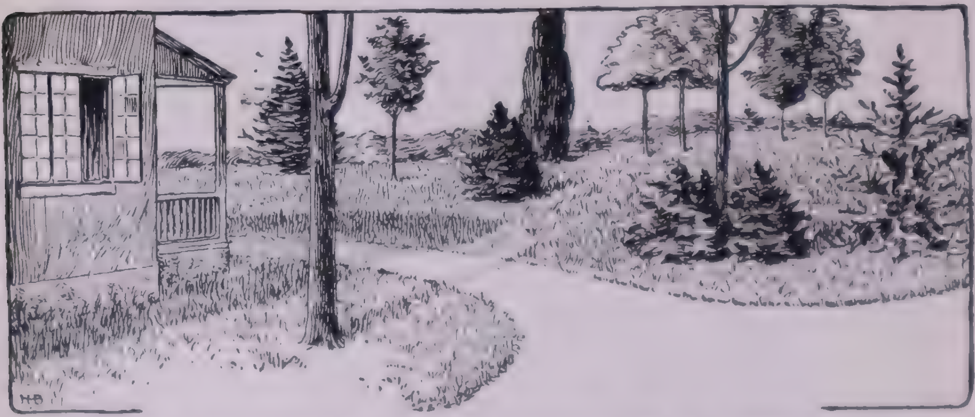


Fig. 71. — A meaningless back yard planting and an unnecessary drive

MAKING A PLAN

Before beginning the actual work of planting, it is much more satisfactory to make first on paper a general plan of the grounds. This may be done in late winter before any work can be done outdoors. One should then send to the seed houses and nurserymen for catalogues. This general plan should consist of a map of the grounds drawn to a proper scale, showing the location of the buildings, walks, and boundaries (fences, hedges, etc.) and any trees, shrubs, vines, or other things already planted. Then on this plan should be arranged such other plants, in the desired locations, as one may wish to set out. The location of each shrub may be indicated by means of a number. It is well also to make separate plans of the flower and vegetable gardens on a larger scale, showing exactly what is to be planted and the location. These plans will enable one to work to better advantage in the spring and to secure more satisfactory results. If one does not like the first plan made, it is a simple matter to make another. In carrying out a plan to beautify the yard, five kinds of plants may be used: grass (lawn), shrubs, vines, flowers, and trees.

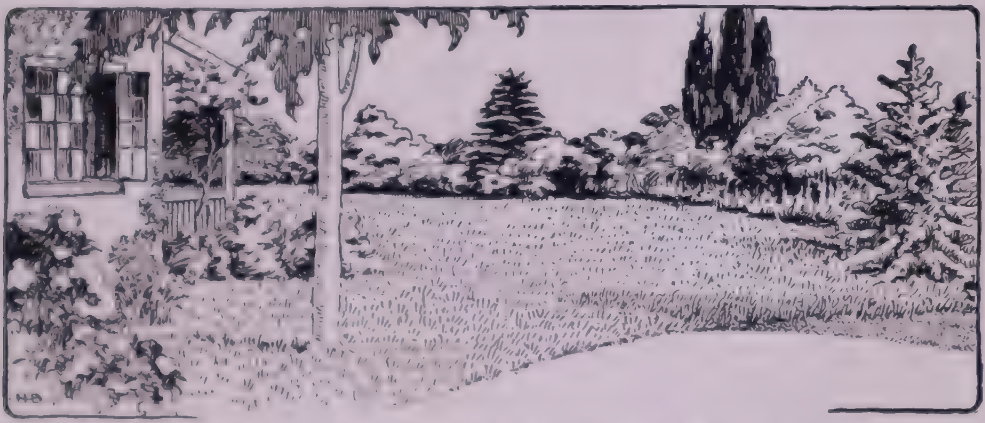


Fig. 72. — Suggestions for improving Figure 71

THE LAWN

Importance. The first and most important feature to consider is the lawn. This is the background against which other plants are to look their best, and the lawn in itself is a beautiful part of the yard. The lawn should be smooth but need not necessarily be perfectly level.

Methods of starting. Lawns may be started in two ways — by seed and by sod. Each method has its advantages; the use of seed is cheaper, while the sod gives quicker results. Sod is much better than seed on terraces or other slopes from which the soil might be washed away before the seed got a start. For most situations the use of seed is preferable.

Care of lawn. The chief thing to consider in caring for the lawn is the mowing of it. The clippings need not be raked up; in fact it is better to let them lie, as they form a protection for the roots and eventually decay to make humus. If the conditions are such that the lawn can be watered, it should be thoroughly soaked. A little sprinkling may do more harm than good, because the roots may turn and grow upward if the soil above is more moist than that below. The soil may be enriched by spreading manure on the lawn in the late autumn.

SHRUBS

Uses of shrubs. Having secured a mat of living green through a well-kept lawn, we may next consider the plants that may be set out here to make the yard more attractive. First in importance are shrubs. These serve several valuable purposes: they are attractive in themselves; they make an excellent background for the flower garden; they may screen unsightly objects; and as a hedge they may serve in place of a fence to mark a boundary.

Selection of shrubs. In selecting the kinds of shrubs, one may consider the following characteristics: hardiness, height, time of bloom, color of flowers, and fruit. In the northern states hardiness is the first consideration. By hardiness is meant the ability of the shrubs to withstand the winters. If one knows the height of the shrubs when mature, he can select them according to their proposed location and he will know how to arrange them in groups according to their size. Knowledge of the time of blooming will enable one to select shrubs which give a succession of bloom, thus prolonging the blooming season. In the more northern sections the following combination gives a long succession of bloom: bridal wreath, mock orange, Bumalda's spirea, ash-leaved spirea, and hydrangea. A knowledge of the colors of the flowers will enable one to so arrange the shrubs as to give harmonious combinations.

The following table is given for reference, to show the chief characteristics of a few of the more common shrubs:

NAME	HEIGHT	TIME OF FLOWERING	COLOR OF FLOWER
Small Shrubs			
Flowering almond .	4 feet	May	Rose
Japanese barberry .	3–4 feet	June	Red and yellow
Deutzia gracilis . .	3–4 feet	June	Rose white
Medium-sized Shrubs			
Golden bell . . .	8 feet	April	Yellow
Panicled dogwood .	8 feet	April-May	White
Hydrangea paniculata	6 feet	Aug.-Sept.	White
Spirea Van Houttei .	6 feet	June	White
Japanese snowball .	7–9 feet	May	White
Weigelia candida . .	6–7 feet	All summer	Pink
Large Shrubs			
Lilac	10–15 feet	May	White and purple
Mock orange . .	10 feet	June	White
Ninebark	10 feet	June	White

Arrangement of shrubs. In setting out shrubs there are certain principles that will help one to obtain artistic effects. There are three essentials which have been called the A B C of landscape gardening.

First, the shrubs and flowers should be placed around the edge and borders of the lawns, and not in the center, which should be kept free and open. This open center forms an important part of the general effect and also tends to make the area seem larger than when the shrubs are scattered over the lawn. Shrubs may be planted not only along the borders, walks, and driveways but also in front of porches and buildings, especially at angles and corners, thus helping to soften the harsh lines of the buildings. Someone has well said that the lawn is the picture and the shrubbery the frame.

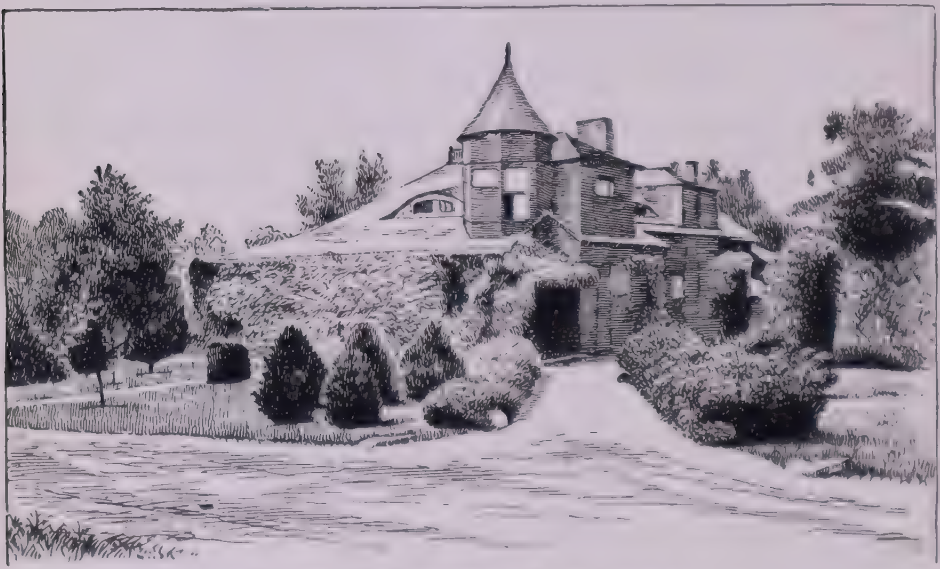


Fig. 73. — Planting of shrubbery

Second, the plants should be grouped in masses. If one wishes to plant three shrubs, he should place them near enough to each other to give the effect of one mass instead of placing them so far apart that each stands out by itself.

Third, the plants should not be set in straight lines. If a border is to be made of the plants, they should be arranged in a curving line if the yard is large. This rule does not apply so closely to a small yard, in which for lack of room it may be necessary to plant the shrubs nearly in a straight line.

VINES

Two features of vines make them specially desirable in adorning the yard: first, their ability to climb; and second, the great length to which they grow. Vines are adapted for growing on porches and buildings.

Classes of vines. Vines are divided into two classes: annual and perennial. The annual vines, such as the morning glory, live only one season and must be grown from seeds every year; perennials live more than two years. There are two types of perennial vines: the woody and the herbaceous. With the woody vines, such as the woodbine, both the root and the stem live over the winter, while with the herbaceous vines, such as the clematis, the root lives over the winter and the stem dies.

How vines climb. Vines have a variety of ways by means of which they climb. Some, as the morning glory, are called *twiners* because the whole vine twines around a support. Some twine in the direction in which the hands of a watch move, while some twine in the opposite direction. The nasturtium is an example of a *leaf twister;* the petioles of the leaves twist around the support. The grapevine has *tendrils*. The woodbine has *aërial roots* with disk-like suckers at the ends, which adhere closely to the support on which the vine is growing.

Providing supports. In selecting a vine to grow on a building, one must consider the means by which it climbs. Woodbine and ivy are especially desirable to grow on buildings of stone, brick, or concrete, because, without other support, their aërial roots will attach themselves directly to a wall. It is not advisable to grow vines directly on wooden buildings. Some support, such as netting or wires, should be provided to keep the vines away from the building.

FIELD EXERCISE 2

Purpose. To study those shrubs and vines that are adapted for growing in the home grounds.

Directions. 1. Visit parks, private grounds (if permission can be obtained), and thickets where wild shrubs grow, in order to identify some of the common shrubs and vines that have ornamental value. The flowering effects of most of the common shrubs can best be observed in the spring.

2. Notice to what extent the principles explained in this chapter are carried out in the location and arrangement of shrubs that men have planted and in wild thickets.

3. Make a study of the different kinds of shrubs to note their attractive features and to see how the shrubs can be identified. For each shrub studied, record the following points in your notebook:

a. Name of shrub
b. Leaves
    (1) Arrangement (opposite or alternate)
    (2) Kind (simple or compound)
    (3) Margin (entire, toothed, or lobed)
    (4) Draw leaf
c. Flowers (brief description)
d. Fruit (brief description)
e. Height
f. Features that make it adapted for planting in the home grounds
g. Chief characters by which identified

4. A similar outline may be used for vines. Note also the method of climbing and the support on which the vine grows.

5. Draw plans of some attractive yards and write down the names of the shrubs found growing there. The location of a shrub on a plan may be indicated by a small circle with a figure in the center to represent the kind of shrub. For example, bridal wreath may be shown thus ① and mock orange may be shown thus ②.

THE FLOWER GARDEN

Location. The flower garden should not be placed in the center of the lawn; it may be placed around the edge of the yard, bordering the walk, next to the fence, in front of the porch or house, or in front of the shrubs. Most plants grow better in the direct sunlight; if the garden is placed near the porch, it should be in a sunny location.

In selecting the seeds to be planted, one needs to know three things about the flowers: their color, time of blooming, and height. If the border can be made wide enough so that two rows can be planted, the taller should be planted behind and the shorter ones in front. By noting the month when flowers are in bloom, one may make such a selection that the garden will have some flowers in bloom during the entire season. Each individual may make such combinations of colors as he prefers.

Perennials. We find the same two classes of flowers as of vines: perennials and annuals. While the tops of perennials die down in the fall, the underground parts live during the winter and send up new stalks each spring. Each year they increase in size, making large clumps; and pieces of the root may be cut off and used to start new plants. On account of their permanency, perennials may well form an important part of the flower garden. Seeds may be planted in April and the plants will bloom the second summer. Seeds may also be sown in August and September, in which case many will flower in the following summer. The seeds are rather slow to germinate and require good care. Plants may also be bought and set out either in the spring or in the fall. The advantage of raising perennials from seeds is their cheapness, the plants themselves being rather high priced; the advantage in buying plants is that one gets quicker results.

TABLE OF PERENNIALS

NAME	COLORS	TIME OF BLOOM[1]	HEIGHT
Anemone Japonica	White, pink	Aug.–Sept.	2 feet
Aster	Blue	Sept.–Oct.	2–6 feet
Bocconia cordata .	White	July–Aug.	3–6 feet
Candytuft . . .	White	May–June	½–1 foot
Cardinal flower .	Red	July–Aug.	4 feet
Chrysanthemum .	All colors but blue	Sept.–frost	3 feet
Columbine . . .	Blue, white, yellow	May–June	1½–3 feet
Foxglove . . .	White, rose, purple	June–July	2–3 feet
Gaillardia . . .	Yellow	July–Oct.	2 feet
Golden glow . .	Yellow	Aug.–Sept.	6 feet
Hollyhock . . .	White, yellow, rose, purple	Aug.	4–5 feet
Larkspur . . .	Blue	June–July	4 feet
Moss pink . . .	Pink	May–June	½ foot
Peony	White, rose	June	3 feet
Poppy	Yellow, scarlet	June–July	2–3 feet
Sweet William .	Pink, red, white	June–July	1–1½ feet

[1] For latitude of New York City.

Bulbs. It is easy to raise flowers from bulbs. The labor of planting them is small; and after they are once set out they require little care. Most of the fall bulbs may be allowed to remain for several years in the same situation, where they will bloom each year. Some will do better, however, if they are taken up and transplanted every few years.

Fall bulbs. Bulbs may be divided into two groups in accordance with the time of planting: fall bulbs and summer bulbs. Fall bulbs are planted in the fall and blossom in the following spring and summer. This group includes most of the common bulbs, such as crocus, hyacinth, tulip, narcissus, and lily. Summer bulbs are planted in the late spring and early summer and blossom in the summer and fall. The gladiolus and the tuberose are examples of this class.

The fall bulbs may be set out from the first of October to the middle of November. About the middle of October is the best time for the latitude of New York City. The depth at which the bulbs should be planted depends upon the size of the bulb; the larger the bulb, the deeper it is set. A general rule is to cover bulbs twice their diameter. After the bulbs are set out, they develop a root system before the ground freezes; and thus they are able to start into growth as soon as the warm spring days begin. These bulbs are especially desirable because they bloom in the early spring, beginning with the melting of the last snows and continuing on into midsummer.

Summer bulbs. The more common kinds of summer bulbs are gladiolus, cinnamon vine, dahlia, and tuberose. Gladiolus may be planted from the middle of April until the last of June. The flowers have a great variety of colors. The cinnamon vine is valued because it grows rapidly, reaching a height of from ten to thirty feet in a single season. It may be set out the latter part of April.

The dahlia is one of the most popular flowers, blooming in August and September. The part planted is really a root instead of a bulb, but it may be considered here. The roots may be planted from the middle of May until the first of July. They should be set about three inches deep. Tuberose bulbs may be set out the last of May, and they should be covered about an inch. The last flowers appear during the latter part of September.

All these summer bulbs are tender and must be taken up in the fall and stored during the winter. After being dug up, they should be left in the sun and air for a few hours to cure, and then they should be stored in a cool, dry place where they will not freeze.

Annuals. The seeds of annuals are planted in the spring;

the plant develops rapidly, and dies on the approach of cold weather. Some annuals are hardy, such as the sweet pea, and may be planted as soon as the ground thaws in the spring; while others, such as the portulaca, are tender and should not be planted till danger from frost is past. The great disadvantage of annuals, as shown in the following table, is the fact that there are none which bloom in the spring and early summer.

Some of the characteristics of a few common annuals and some details regarding the planting of the seeds are given in the table on page 201. The dates given are for outdoor planting. The seeds may be started in the house earlier and the plants then transplanted. In this way the flowers may be secured several weeks sooner. These dates are for the latitude of New York City; for other localities, allow six days' difference for each hundred miles in latitude: north, the dates for planting and time of bloom are later; south, they are earlier.

Fig. 74. — Border of four o'clocks

TABLE OF A FEW COMMON ANNUALS ARRANGED IN THE ORDER IN WHICH SEEDS MAY BE PLANTED

NAME	HEIGHT (FEET)	COLOR	TIME OF BLOOM	TIME TO PLANT	DAYS REQUIRED TO COME UP	DISTANCE TO THIN OUT (INCHES)
Sweet pea . .	4–6	Purple Scarlet White Yellow Pink	June–Oct.	March	7–20	4
Poppy, California	1	Scarlet Yellow	July–Aug.	April 1	12	6
Nasturtium .	1–6	Orange Red Yellow White	July–Oct.	April 15	10	6
Alyssum . .	½	White	July–frost	April 15	7	6
Phlox . . .	1	Scarlet Pink White	Sept.–Oct.	April 15	10	6
Zinnia . . .	1½–2	Red Scarlet Yellow	July–Oct.	April 15	5	6
Ageratum . .	½	Blue	Aug.–Sept	May 1	7	6
Cornflower	1–2	Blue	July–Sept.	May 1	5	6
Four o'clock .	2–3	Crimson White Yellow	July–Oct.	May 1	12–14	24
Aster . . .	1	Blue Red White	Sept.–Oct.	May 10	5–10	6
Balsam . .	1–2	Pink Red White	July–Aug.	May 10	8–10	8
Cosmos .	4–6	Pink Red White	Oct.–Nov.	May 15	5–10	12–24
Marigold . .	1–2	Yellow	Aug.–Oct.	May 15	5	8
Petunia . .	1–2	Magenta White	Sept.–Oct.	May 15	10–30	10
Portulaca . .	½	Red White	July–Sept.	June 1	5–15	4

Annuals for shady places: Clarkia, forget-me-not, Godetia, musk plant, nemophila, pansy.

Comparison of annuals and perennials. Annuals and perennials have each their advantages. The advantages of the annuals are the following: First, one gets much quicker returns from them, as the flowers are obtained the same season that the seeds are planted, while with the perennials one must wait till the second season. This advantage is an important consideration to people who do not own their homes but rent them for a year at a time. Second, it is possible to obtain a greater variety of combinations from year to year. Since the garden is started entirely anew each year, any new combinations or varieties can be tried. With the perennials, it is much more difficult to make changes after the plants are once established.

The advantages of the perennials over the annuals are the following: First, with the perennials it is possible to make the flowering season nearly twice as long, since some of the perennials begin to bloom in the early spring, and from this time on a continuous succession can be obtained till late fall. The first of the annuals do not begin to bloom till well into the summer. Second, after the first season, perennials require less care than annuals; and they are established for many years.

The ideal arrangement is to have a combination of both annuals and perennials. The perennials may make the chief background of the garden, and spaces may be left between for the annuals, which may be changed from year to year as one wishes.

FIELD EXERCISE 3

Purpose. To identify some of the cultivated flowers and to note their attractive features. (Fall and spring.)

Directions. 1. Visit parks and private grounds and study the flowers found there. For each plant studied, record the following points in your notebook:

- *a.* Name
- *b.* Flowers
    - (1) Colors
    - (2) Size and shape
    - (3) Arrangement
    - (4) Odor (strong or weak, pleasant or offensive)
- *c.* Leaves (record the most conspicuous features)
- *d.* Height of plant
- *e.* Kind (annual or perennial)
- *f.* Chief characteristics by which identified

2. After you have finished your study of a number of flowers, select the five that you like best.

OUTLINE SUMMARY

Planting the Home Grounds

- I. Reasons for gardening
- II. Making a plan
- III. The lawn
    - 1. Importance
    - 2. Methods of starting
    - 3. Care of lawn
- IV. Shrubs
    - 1. Uses
    - 2. Selection
    - 3. Arrangement
- V. Vines
    - 1. Classes of vines
    - 2. How vines climb
    - 3. Providing supports
- VI. The flower garden
    - 1. Location
    - 2. Perennials
    - 3. Bulbs
        - *a.* Fall bulbs
        - *b.* Summer bulbs
    - 4. Annuals
    - 5. Comparison of annuals and perennials

QUESTIONS FOR CLASS DISCUSSION

1. Why is it better to begin gardening by making a plan?
2. What should be taken into account (*a*) in selecting the kinds of plants for ornamentation and (*b*) in setting them out?
3. What is the special value of vines?
4. Which would you rather have, a flower garden of annuals or one of perennials? Why?
5. Why are bulbs specially desirable to plant?
6. How should bulbs be planted and cared for?
7. What care does the flower garden require?
8. What are the chief values of gardening?

REFERENCES

Baker, *Yard and Garden.* Bobbs-Merrill Co., Indianapolis.

Bailey, *Manual of Gardening.* The Macmillan Co., New York.

"Blanchan," *The American Flower Garden.* Doubleday, Page, and Co., New York.

CHAPTER XIV

THE HOME VEGETABLE GARDEN

The Tools

The tools absolutely required are few in number, the three most essential being the hoe, the rake, and the spade or spading fork. In addition, however, a flat file for sharpening the hoe, a trowel, and a garden line will prove very useful. Two strong, pointed stakes should be provided to use with the line. If one has a large garden, it will pay to secure a wheel hoe. It saves many backaches and enables one to do the work of caring for the garden in very much less time and with much more pleasure. The two most important attachments are the hoes and the cultivator teeth.

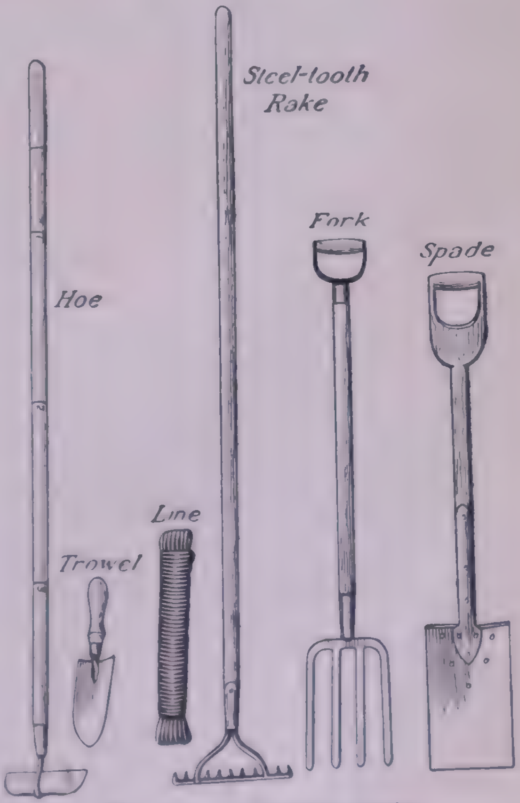


Fig. 75. — Garden tools

The Plan

Making the plan. In the late winter or the early spring before the planting is begun, a map of the garden may be drawn on paper. The vegetables to be planted should be decided upon and the names written in the proper places on the paper; the number of rows of each kind of vegetable and the distance between the rows should be indicated. First, however, the dimensions of the garden should be measured and recorded on the plan. While it is not necessary to make a plan in order to have a satisfactory garden, yet a plan will probably give better results; and the making of the plan affords some pleasure. During the late winter one may study seed catalogues and make the plan before any outdoor work is possible. In connection with making a plan, it is well to consider successive plantings and double cropping.

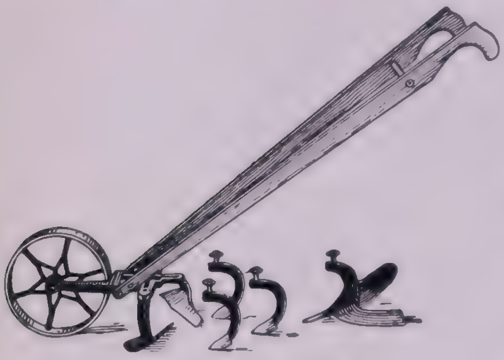


Fig. 76. — Wheel hoe

Fig. 77. — A home garden

Successive plantings. If the garden is large enough, arrangements should be made for a succession of crops. The

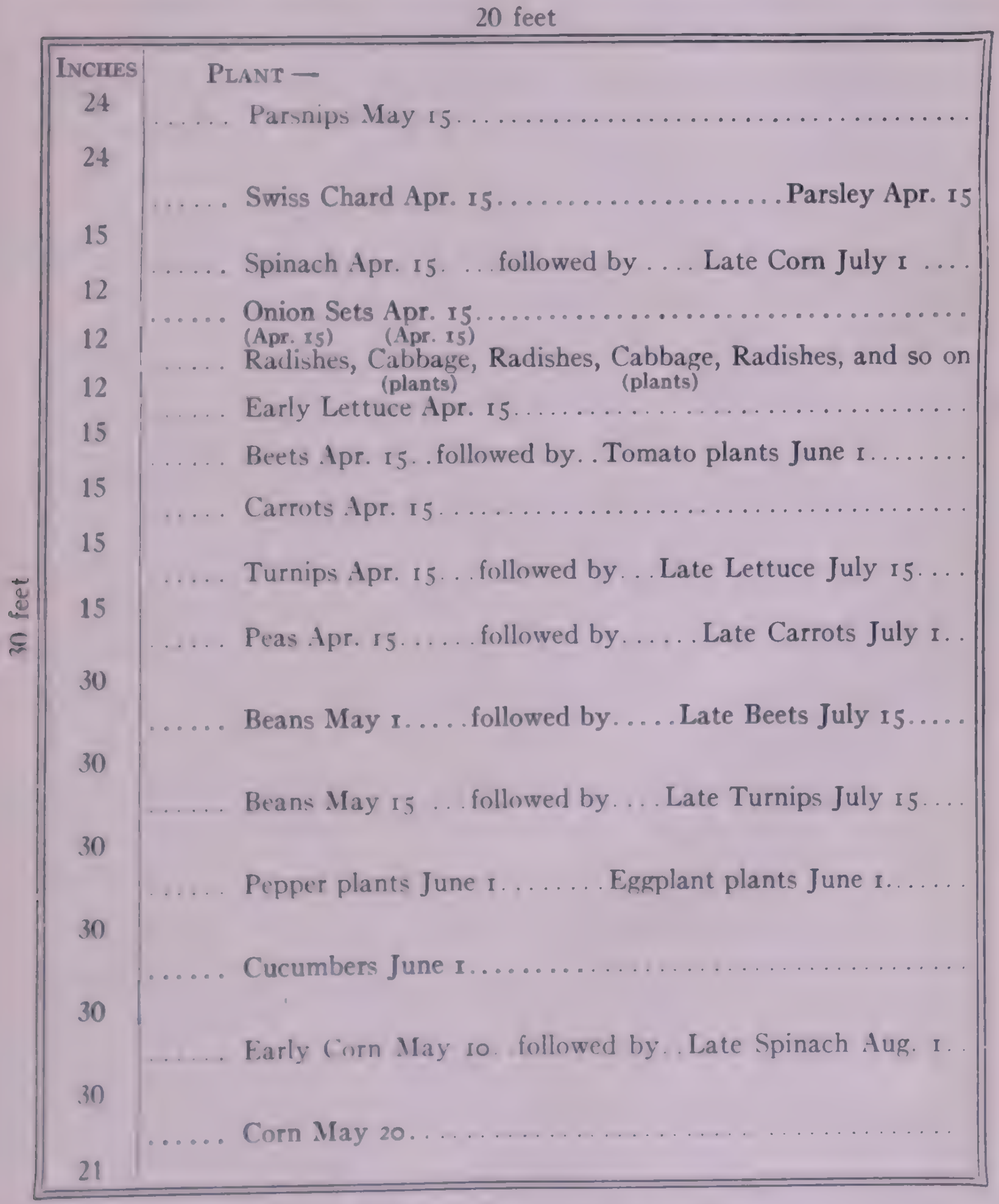

20 feet
30 feet
Inches
Plant —
24
...... Parsnips May 15 ......
24
...... Swiss Chard Apr. 15 ...... Parsley Apr. 15
15
...... Spinach Apr. 15 ... followed by .... Late Corn July 1 ....
12
...... Onion Sets Apr. 15 ......
12
(Apr. 15) (Apr. 15)
..... Radishes, Cabbage, Radishes, Cabbage, Radishes, and so on
(plants) (plants)
12
..... Early Lettuce Apr. 15 ......
15
...... Beets Apr. 15 .. followed by .. Tomato plants June 1 ....
15
..... Carrots Apr. 15 ......
15
..... Turnips Apr. 15 ... followed by ... Late Lettuce July 15 ....
15
...... Peas Apr. 15 ...... followed by ...... Late Carrots July 1 ..
30
...... Beans May 1 ..... followed by ..... Late Beets July 15 .....
30
...... Beans May 15 ... followed by ... Late Turnips July 15 ....
30
...... Pepper plants June 1 .... Eggplant plants June 1 ......
30
...... Cucumbers June 1 ......
30
...... Early Corn May 10 followed by .. Late Spinach Aug. 1 ..
30
...... Corn May 20 ......
21

Fig. 78. — Plan of a vegetable garden

same kinds of seeds should be sown at intervals of a week or two, so that when the plants from the first seeds have stopped bearing, those from the second will be maturing. This succession may be arranged with those vegetables that mature quickly, such as radish, lettuce, peas, beets, corn, and beans. Another way to secure a succession is to buy varieties which require different lengths of time to mature and to plant them all at the same time. Since some vegetables require the whole season to mature, generally only one crop of these is raised: such are parsnips, salsify, melons, and pumpkins. Seeds of beets and turnips that are to be stored for the winter should be planted in the middle or latter part of the summer.

Double cropping. *Succession cropping.* In order to raise the most on a certain area, the ground should be kept in use all the time. Raising two crops on the same area is called double cropping, of which there are two kinds — succession cropping and companion cropping. In succession cropping, as soon as one kind of vegetable has matured and has been harvested, something else is planted in the same place. For example, radishes and lettuce may be followed by late corn; early beets, by cauliflower or eggplant; peas, by summer lettuce; early corn, by cabbage plants or spinach.

Companion cropping. In companion cropping, the two crops occupy the ground at the same time, one being planted between the rows of the other. Those plants must be selected that mature at different parts of the season, one early and the other late, so that the early crop may be gathered and the plants pulled from the soil before they shade the second crop. Thus tomato plants or corn may be planted between rows of early peas; and when the peas have been picked, the vines are pulled from the soil to give room for the other crops. Other examples of companion cropping are radishes between the rows of beets or carrots, the radishes maturing before the beets or carrots need the room; squashes, pumpkins, or climbing beans planted in the hills of corn; early onions with cabbage. Giving attention to double cropping is one of the secrets of success in raising large crops of produce on small areas.

The perennial vegetables, such as asparagus and rhubarb, should always be grown on one side of the garden, so that they will not interfere with plowing in future years.

SELECTION OF VEGETABLES

In deciding upon the vegetables to be planted several considerations should be taken into account, such as family likes and dislikes and the size of the garden. In a small garden those vegetables should be avoided which require a large area for the returns yielded, such as melons, pumpkins, squashes (excepting the summer squash), and potatoes.

Varieties. It is important to consider the matter of the most suitable variety of each vegetable planted — that is, the different kinds of peas, corn, etc. Varieties differ in yield, taste, size, time required for maturing, and character of growth — such as climbing peas and beans and the dwarf or bush varieties. There are early peas and late peas, early corn and late corn. One interesting feature of gardening is the opportunity to try out new varieties each year.

HOW TO GET EARLY VEGETABLES

Hotbed. Early vegetables may be obtained through the use of hotbeds, cold frames, and seed boxes. A hotbed is a shallow box covered with glass. While it may be placed on the surface of the ground, it is better to have it sunk into the ground for a part of its width. The earth inside is taken out and a thick layer of fresh horse-manure is placed in the bottom; this is then covered with soil. The decaying manure furnishes heat, which keeps the hotbed up to a high temperature. In the hotbed such plants as cabbage, lettuce, celery, and tomato may be started from one to two months earlier than they could be planted outdoors.

The bed must be carefully watched. The cover must be shut down at night to prevent the young plants from freezing and must be opened during the day to allow ventilation. The bed must also be watered. These plants are later transplanted to a cold frame, where they are gradually hardened, and then they are set out in the garden. If one has a large enough frame, some plants, like lettuce, may be allowed to mature in the hotbed.

Cold frame. A cold frame is made in the same way as a hotbed, only no manure is put in to furnish artificial heat. Besides being used to harden the plants started in the hotbed, it may also be used to start seedlings, on the same principle as the hotbed, but later. Seeds can be planted in the cold frame three or four weeks earlier than they could be planted in the garden. A simple cold frame can easily be made. A box of any desired size may be partly sunk into the ground in a sunny location, tipping toward the south, and then covered with panes of glass.

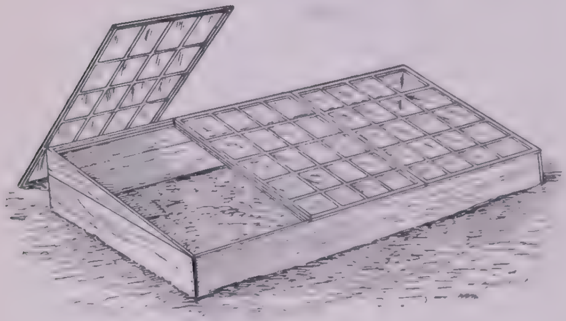


Fig. 79. — Cold frame

Seed box. A seed box is a shallow tray in which seeds can be started indoors. A seed box may be placed in a sunny window, and three or four weeks' time may be gained in this way. Plants that are grown in hills — like corn, melons, and cucumbers — may be planted in strawberry boxes indoors early in the season. When danger from frost is past, the bottom of the box may be cut off and the whole box sunk in the ground.

SCHOOL PROJECT 3

Purpose. To raise seedlings of some vegetables in the schoolroom so that they may be taken home and planted in your gardens.

Directions. Those who are interested can work together to raise seedlings of some plants — such as lettuce, cabbage, and tomato — in boxes in the schoolroom. For this purpose shallow flats can be made and the seeds planted in them. Care should be taken to see that the plants do not freeze between Friday and Monday. When it is time to set the plants outdoors, they may be divided among the members of the class and taken home.

PARTS OF A GARDEN PLANT

In order that garden plants may thrive, certain care must be given them by the gardener; and if one understands the reasons for the work he must do in the garden, he can work more intelligently and with greater pleasure. Therefore let us examine a common garden plant, such as the bean, to see what work it does and how it carries on this work.

A growing bean plant is just as truly a living thing as is a dog or another animal, only it shows its life in a different way. One of the chief differences between the two, of course, is that the plant is fixed in position and cannot move from place to place as can the dog. On the other hand, the bean plant can do certain things that the dog cannot do. In fact so important is one of these activities of the plant that without it neither man nor the other animals could live. Hence man's very life is dependent on plants.

A study of a bean plant shows that it consists of the following parts: root, stem, leaf, flower, and fruit. Each of these parts performs certain duties to aid the plant in carrying on its life activities, the two chief ones being the manufacture of foods and the formation of seeds. The parts of the plant concerned in the making of food are the root, the stem, and the leaf; the parts concerned in the formation and distribution of seeds are the flower and the fruit.

Manufacture of food. The first food made by plants is starch; and in this work the root, the stem, and the leaf each takes a part. The actual work of making the starch is performed in the leaf by the green matter called chlorophyll. In order to make starch the leaf must be supplied with water and carbon dioxide. The work of the root is to absorb water from the soil through tiny appendages known as root hairs. At the same time, these hairs are taking in the mineral matter dissolved in the water. "Osmosis" is the name given to the process by means of which the mineral matter passes through the walls of the root hairs. It has been found that osmosis proceeds in accordance with the law that the substances in solution pass from the lighter to the denser liquid. Therefore, following this law, the water with its dissolved minerals passes from the soil through the walls of the root hairs.

This liquid then passes up through the stem and into the leaf, where it is used in the process of making starch. However, much more water is brought up than is used; and the excess is passed out through tiny openings in the epidermis of the leaf, known as stomates. This process of evaporating water from the leaf is called transpiration.

Besides water, the other material that the leaf needs in making starch is a gas — carbon dioxide — which is found in small quantities in the air. This gas enters the leaf through the same stomates by which the water passes out. As a result of this activity of the chlorophyll in the presence of sunlight, starch is formed, and oxygen is given off as a waste product.

In addition to making starch the plant also manufactures other foods known as proteins. These are made from the starch and the mineral matter taken in by the root.

These starches and proteins form the foundation for man's food supply. Sometimes we eat the vegetable foods directly; in other cases we eat animal food, but the animals that supply us with animal food have eaten vegetable food; thus man is dependent entirely upon plants for his food and hence for his life. Therefore, as one observes the green color of the leaves of our garden and farm plants, it will be interesting to recall the fact that man's life depends on the work done by this green chlorophyll.

Formation of seeds. The second great work of the bean plant is reproduction — that is, the formation of seeds which shall continue the life of the species after the bean plant itself is dead. The flower is the part of the plant involved in the formation of seeds. The first step in this process is the transfer of pollen by insects or — as in the case of corn — by wind from a stamen to a pistil. Following this pollination there takes place a process known as fertilization, in which a pollen grain unites with an ovule located in the pistil. The last stage in the process is the development of a seed as a result of fertilization. At the same time certain other tissues develop in connection with the seeds; and these (such as the pod of the bean) together with the seeds constitute the fruit of the plant.

A seed is really a small plant without roots. When the conditions of moisture and temperature favorable for germination are provided, as when the seed is planted in the garden, roots begin to form; and the little plant grows till again we have a mature bean plant. Thus the cycle goes on year after year.

Man raises these garden plants to supply himself with food. Sometimes he uses the root for food, as the beet; sometimes the leaf, as the lettuce; or again it may be the seed, as the bean; or the entire fruit, as the cucumber.

PREPARATION OF SOIL

In order to get the best results, the soil should be enriched with manure or fertilizer. It should be plowed or thoroughly spaded as soon in the spring as it can be worked. Special attention should be given to the preparation of the soil where seeds are to be planted. It should be gone over with a rake, the lumps taken out, and the top soil left in fine condition.

PLANTING THE SEEDS

The garden line should be used to lay out the rows straight. The garden should be planted in long rows rather than in short beds, as this plan makes the work of cultivating the garden much easier, especially if a wheel hoe is used. If one row is more than a person desires to plant with one kind of seed, then the remainder of the row may be planted with some other seed that requires about the same space between the rows. In planting seeds, three things need to be considered: the time, the distance, and the depth.

Time. The time of the first planting of seeds depends upon the hardiness of the seedlings to frosts. This time varies with the latitude and with the season, according to whether the spring is early or late. For a few seeds the average time in the latitude of New York City is given in the table on page 221. Vegetables may be divided into two groups — hardy and tender. The hardy vegetables, such as radishes and peas, can stand the light frosts of spring and so may be planted as soon as the soil is in good condition to work. The tender vegetables, such as cucumbers and tomatoes, are killed by the frosts and so cannot be planted till the danger from frost is past, usually about three or four weeks after the hardy vegetables are planted.

The time of the last planting of seeds depends on two factors: the length of time it takes the plant to mature, and the date of the first killing frost in the autumn.

Distance. Distance in planting seeds depends on the size of the mature plant. Space enough should be allowed to give the plants room to grow without crowding. Some seeds, such as peas, are scattered along the rows in drills, while others, such as corn and potatoes, are planted in hills at certain stated distances.

Depth. The depth of planting seeds depends chiefly on their size, the larger seeds being planted at a greater depth. A general rule is to plant a seed at a depth of two or three times its smaller diameter. The depth of planting a few common seeds is given in the table on page 221.

LABORATORY EXERCISE 9

Purpose. To make a plan of a vegetable garden.

Directions. 1. On a piece of unruled paper make a plan to scale of some part of your yard that could be used for a garden.

2. Follow the suggestions on garden making given in this chapter. Plan for successive plantings and for double cropping.

3. From the table on page 221, select the vegetables that you wish to grow. Draw lines on the paper to represent rows. On each line write the name of the vegetable to be grown, and after it write (1) distance between rows and (2) date of planting. Use all the space and make the sum of the distances between the rows equal the width of the garden.

THINNING

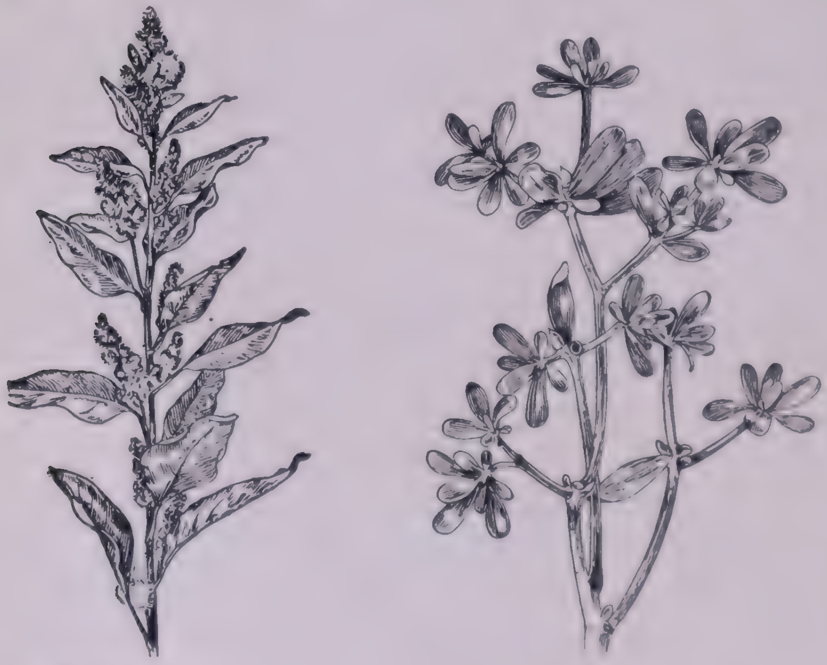
It is important that the young plants should be thinned out when they are two or three inches high. The distance to which they should be thinned is given in the table on page 221. When the plants are crowded together, there is not room for all to develop, and the result is a large number of small, inferior specimens.

TRANSPLANTING

Transplanting is best done on a cloudy day or late in the afternoon. It is well to water the plants a few hours beforehand, so that when they are taken out some earth will adhere to the roots. If the ground is very dry, the plants should be watered after they are set out. Sometimes it may be desirable to protect the young plants from the sun's rays by means of paper or other devices. Not only may plants be transplanted from the hotbed and the cold frame, but when beets, lettuce, and such plants are thinned, the extra plants may be set out.

CULTIVATION OF SOIL

After the plants have once got started, the essential point in caring for them is to hoe the ground around them often. This hoeing serves several purposes: first and most important, it keeps down the weeds; and second, it mixes air with the soil for the roots to use. The hoeing should be repeated often enough to keep the garden free from weeds and should be done when the little weeds first appear above the soil, before they have had an opportunity to take moisture from the soil.



Rough pigweed **Purslane**

Fig. 80. — Two common weeds of the garden

ENEMIES OF THE GARDEN

Weeds. Two common enemies with which one must contend are weeds and insects. Most soil is filled with seeds of weeds, some of which may live in the soil for many years and then germinate. Some have been known to live as long as fifty years. It is a common thing for seeds to live ten or fifteen years. When the conditions for seed germination arrive in the spring, many weed seeds sprout in the garden. If the seedlings are allowed to grow, they reduce the yield of the garden, because they rob the garden plants of water and plant-food in the soil and they deprive the plants of sunlight. Weeds also make the garden look unsightly. One of the important things to do in caring for a garden is to keep down the weeds by hoeing.

FIELD EXERCISE 4

Purpose. To identify the most common weeds found growing in vegetable gardens.

Directions. 1. In the fall a trip may be taken to some gardens in the vicinity in order to identify some of the more common weeds.

For each weed studied record the following points in your notebook:

- *a.* Name
- *b.* Height
- *c.* Character of growth (erect or prostrate)
- *d.* Leaves
  - (1) Size and shape
  - (2) Arrangement (opposite or alternate)
  - (3) Margin (entire, toothed, or lobed)
  - (4) Make drawing of leaf
- *e.* Flower (brief description)
- *f.* Fruit and seeds (brief description)
- *g.* Chief characters by which identified

Insects. Insects are another common enemy of the garden. Some plants grow without much interference from insects, while other plants are almost always attacked by them. Insects may be divided into two groups according to their method of doing harm — the biting insects and the sucking insects. The biting insects, such as the potato beetle, devour the solid tissues of the plant, usually of the leaf; the sucking insects, such as the squash bug, suck out the sap from the plant.

The following table, taken from *Farmers' Bulletin 818*, lists the insects most likely to appear in the vegetable garden and furnishes information in regard to the plants attacked and the treatment recommended.

INSECT	PLANTS ATTACKED	TREATMENT
Eating type		
Tomato worm	Tomato	Hand pick or spray with arsenate of lead
Cabbage worm	Cabbage group	Hand pick or apply arsenate of lead
Cucumber beetles	Cucumber and melons	Cover with frames and apply tobacco dust, or spray with Bordeaux mixture or arsenate of lead
Potato beetle	Potato, eggplant, and tomato	Hand pick and apply arsenate of lead
Sucking type		
Squash bug	Squash, pumpkin, melons, etc.	Hand pick and spray with kerosene emulsion or nicotine sulphate
Aphids (plant lice)	Cabbage group and other plants	Spray with kerosene emulsion, a solution of hard soap, or nicotine sulphate

To destroy the sucking insects, the plants are sprayed with some poison, such as kerosene emulsion, which kills the insect by contact or by smothering it. To destroy biting insects the plants are sprayed with some such poison as lead arsenate or Paris green. The insects eat this with the leaf and are poisoned. For small quantities, three teaspoonfuls of lead arsenate or one of Paris green may be used with a gallon of water. In small gardens the insects may be hand picked by knocking off the insects with a stick into a dish containing kerosene.

When setting out plants, as tomatoes and cabbages, they may be protected from cutworms by putting tin cans or a collar of heavy paper around them. A simple way of combating the cucumber beetle found on vine crops is to plant an abundance of seeds (ten to fifteen) in each hill. The harm is done chiefly to young plants. The beetles will not usually kill all of this number; and after the plants have become larger and the danger is past, they may be thinned out to three or four plants. Young plants may also be protected by setting over them a frame covered with cheesecloth.

LABORATORY EXERCISE 10

Purpose. To study the activities of some garden insects.

Apparatus. Insect breeding-cages; garden insects.

Directions. 1. Simple breeding-cages may be made out of shoe boxes by cutting a hole in the cover and fastening over it a piece of mosquito netting. Or a lantern globe may be placed in a flowerpot filled with moist sand. Any glass receptacle — such as a canning jar — may be used.

2. Secure insects from the garden, bringing in also a piece of the plant on which they are feeding. Keep them in a breeding-cage and bring in fresh leaves each day to feed them. Secure also some beneficial insects, such as the lady beetle, and some larvæ of the lace-winged fly.

3. Study the various insects, noting in each case: (*a*) general appearance by which it may be identified; (*b*) nature of harm or good done; (*c*) stages in which the insect is harmful or beneficial; (*d*) its method of eating; (*e*) its chief methods of locomotion.

4. If it is desired, the insects may be mounted as explained in Hodges, *Nature Study and Life*, Chapter IV.

STORING VEGETABLES FOR WINTER

If the garden is large enough, the family may be supplied with vegetables not only during the summer but during the winter as well. Many vegetables may be stored in a cool, well ventilated cellar where the temperature does not fall below freezing. A cellar containing a furnace will be too warm and dry, and vegetables stored in it will wilt. If the cellar is warmed, a corner may be partitioned off for storing these vegetables, and ventilation may be procured through a cellar window.

Some vegetables, such as the parsnip and the oyster plant, may be frozen without injury; indeed they may be left outdoors all winter and dug up when needed. Other vegetables, such as potatoes, beets, carrots, and turnips, require a temperature above freezing, from thirty-five to forty-five degrees; and the last three will keep better if buried in moist sand. If the cellar has an earth floor, a very simple way of storing root crops is to dig a shallow, broad trench and place in it beets, carrots, turnips, parsnips, and salsify and then cover them with the earth that has been excavated. Potatoes will keep better if placed in the dark.

Pumpkins, squash, and such vegetables will keep better at a slightly higher temperature, about fifty degrees, and the air should be moderately dry.

To store celery, secure boxes about a foot wide and as deep as the celery is high. Cover the bottom with two or three inches of wet sand. Dig up the celery plants, roots and all. Stand them on the sand, packing them close together. The celery should be sprinkled in such a way that the top of the plant does not become wet. A watering can with a long spout that can be shoved down below the tops will enable one to water the plants in the proper way.

Cabbages and onions may be kept for a few months. Just before the time for heavy frosts, pick the largest green tomatoes and place them on straw in the cellar.

The following table gives in condensed form some of the more important facts regarding the raising of a few common vegetables. The dates for sowing seeds are for the latitude of New York City. They indicate the times for the first and the last planting.

NAME	SEEDS FOR 100 FEET OF ROW	DATE TO PLANT	DEPTH TO PLANT (Inches)	ROWS APART (Feet)	PLANTS IN ROWS (Inches)	DAYS REQUIRED TO COME UP	TIME TO MATURE (Days)
Radish . .	1 oz.	Apr. 15 Sept. 1	½	1	1–2 [1]	4	20–40
Lettuce . .	½ oz.	Apr. 15 Aug. 15	¼	1	4–6 [1]	4–8	60–90
Onion (sets) .	1 qt.	Apr. 15 May	2	1½	3	—	90–120
Peas . . .	1–2 pt.	Apr. 15 June 1	3	2½	1	7–10	40–80
Beets . . .	2 oz.	Apr. 15 Aug. 1	1	1	3–4 [1]	6	60–80
Cabbage . .	¼ oz.	Apr. 15 July 1	½	2	18	6	90–130
Parsnip . .	½ oz.	Apr. 15 June 1	½	1½	3–4 [1]	12–15	125–160
Carrot . .	1 oz.	Apr. 15 June 1	½	1½	2–3 [1]	8–9	75–110
Turnip . .	½ oz.	Apr. 15 Aug. 1	½	1½	3–4 [1]	4	60–80
Potato . .	5 lb.	Apr. 15 June 1	3–5	2	15–18	20	80–140
Corn . . .	¼ pt.	May 1 July 10	2–3	2½	30–36	8	60–100
Beans (bush) .	1 pt.	May 1 Aug. 10	2	1½	2–3	8	40–65
Beans (lima) .	1 qt.	May 15 July 1	2	2½	3	14	90–120
Muskmelon .	½ oz.	May 15 June 1	1	7	72	8	120–150
Cucumber .	½ oz.	May 15 July 1	½	5	60	4–11	60–80
Squash (summer) .	½ oz.	May 15 July 1	1	4	48	11	60–80
Tomato (young plants)	—	May 20 June 15	—	3	36	—	100–140

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[1] Distances to which plants should be thinned. Seeds should be planted much closer.

HOME PROJECT 10

Purpose. To raise vegetables.

Directions. 1. If you have room in your home yard, and if your parents are willing, start a vegetable garden. The purpose may be to raise vegetables either for home use or to sell. First make a plan of the garden. Show it to the instructor to see if he has any suggestions to offer.

2. Keep a record something like the following:

NAME OF VEGETABLE	VARIETY	DATE OF PLANTING	LENGTH OF ROW	DATE ABOVE GROUND	DATE FIRST CROP PICKED	DATE LAST CROP PICKED	TOTAL YIELD	VALUE AT MARKET PRICES

3. Figure out the total value of all the produce raised, and then find the value of the produce per square foot of the garden.

4. Keep an expense account in accordance with the following outline:

DATE	AMOUNT PAID OUT	DATE	AMOUNT RECEIVED
Totals			
Amount earned			

HOME PROJECT 11

Purpose. To test different varieties of some one kind of vegetable.

Directions. Secure seeds of as many varieties of one kind of vegetable as you can. See which are best suited to your garden and which you like best. Send to dealers in seeds for catalogues. For instance, if radishes are chosen, a record like the following may be filled out:

VARIETIES OF RADISHES

NAME OF VARIETY	DATE OF PLANTING	DATE OF FIRST CROP	DAYS TO MATURE	SIZE	SHAPE	COLOR	FLAVOR	YIELD

OUTLINE SUMMARY

THE VEGETABLE GARDEN

I. The tools

II. The plan
  1. Making the plan
  2. Successive plantings
  3. Double cropping
    a. Succession cropping
    b. Companion cropping

III. Selection of vegetables
  1. Varieties

IV. How to get early vegetables
  1. Hotbed
  2. Cold frame
  3. Seed box

V. Parts of a garden plant

VI. Preparation of soil

VII. Planting the seeds
  1. Time
  2. Distance
  3. Depth

VIII. Thinning

IX. Transplanting

X. Cultivation of soil

XI. Enemies of the garden
  1. Weeds
  2. Insects

XII. Storing vegetables

QUESTIONS FOR CLASS DISCUSSION

1. Of what value is the vegetable garden?

2. What things should be considered in deciding on the kinds of seeds to plant?

3. How may the most be raised in a small area?

4. What are the advantages of cold frames and hotbeds?

5. What things must be considered in planting seeds?

6. What care does the vegetable garden require after the seeds are planted?

7. How may one have vegetables during the winter?

8. Which would you rather have, a flower garden or a vegetable garden? Why?

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PART TWO

SCIENCE OF THE COMMUNITY

SECTION A. MEANS OF TRAVEL
    GROUP 1. TRAVEL ON LAND
    GROUP 2. TRAVEL BY WATER
    GROUP 3. TRAVEL BY AIR
SECTION B. MEANS OF COMMUNICATION
SECTION C. THE HEALTH OF THE COMMUNITY
SECTION D. COMMUNITY ENTERTAINMENT
SECTION E. CONSERVATION OF COMMUNITY RESOURCES
SECTION F. WEATHER AND CLIMATE
SECTION G. THE EARTH AND ITS NEIGHBORS

CHAPTER XV

THE LOCOMOTIVE

1. What part does the locomotive play in the life of the community?

2. How is a locomotive constructed and how does it work?

When the white settlers first came to this country, there was no need to travel outside of their little villages. Later, horses were brought over from England; and, as different colonies were established, travel by horseback became common. Still later, the paths were widened to roads, and the stage became the means of fast travel. Finally, this was replaced by the locomotive.

USES OF THE LOCOMOTIVE

Brings necessities of life. The locomotive plays a very important part in our daily life. Not only does it enable us to travel quickly and comfortably from one place to another, but it brings to us also most of the necessities of our daily life. Many of our foods are brought from long distances by means of the locomotive. Oranges are brought from California, early strawberries from Florida, sugar from the southern states, flour from the mills of Minneapolis, and meat from the stockyards of Chicago. If we should make a complete list of all the kinds of food we eat, we should find that the great majority have been brought to us in some part of their journey by means of the locomotive.

It is the same with reference to our clothing. The wool, after being sheared from the sheep, was taken first by locomotives to factories, where it was spun into cloth; it was then again taken by locomotives and carried to other factories, where it was made into clothing; then it was brought to our town, where we finally bought it. Our cotton clothing was made from cotton which was carried by the locomotive from the cotton fields in the South to the mills. It was woven into cloth and then taken to factories where it was made into various articles which were brought to the store and put on sale. The locomotive played an important part in these processes at several different times.

The coal that keeps us warm in the winter is brought to us from the coal fields by the locomotive. The newspapers, magazines, and books that are so important in our life are brought to us by the locomotive. On the payment of two cents for a postage stamp, a letter is carried for us across the continent by the locomotive; in a few days, an answer is brought back.

Indeed, if we think over carefully the things that enter into our daily life — the house in which we live, the rugs upon the floor, the furnishings inside, the piano, the phonograph, and other necessities and pleasures of life — we shall find it difficult to name anything which the locomotive has not, either directly or indirectly, helped to bring to us.

Suburban homes. Another benefit of the locomotive lies in the fact that it has greatly increased the distance that a man may live from his place of business in the great cities. Thousands of business men in great centers of population, such as New York and Chicago, may go at night to their homes miles away in small suburban towns. This plan enables a man to combine the advantages of country life for himself and his family with the advantages of a central location for his business.

Growth of the United States. The locomotive has had a tremendous influence on the development of the United States. As we think of the vast reaches of plains and the great chains of mountains extending across our country, we can readily appreciate how slow must have been the growth of the country without the aid of the locomotive. Many parts of the United States which now support a prosperous population would not even be open to settlement had it not been for the locomotive.

Travel. The locomotive has made travel easy and cheap, so that while a century ago few people traveled beyond the confines of their own towns, today it is common for people to travel over all parts of the United States. The knowledge gained of how other people live has a broadening influence and tends to produce a feeling of tolerance for others; and travel thus results in more harmonious coöperation between different sections of the country.

History of the Steam Engine and the Locomotive

The steam engine and the locomotive play so important a part in our lives today that it is difficult to see how we could get along without them; and yet the railroads in this country have all been developed within the last hundred years. It will be interesting to look at the history of the steam engine and the locomotive to see the changes through which they passed while developing their present form.

Early inventions. The first steam engine was made in 120 B.C. by Hero of Alexandria, in Egypt. This engine was so arranged that steam in escaping from small tubes on a flask caused it to rotate in much the same way that a lawn sprinkler revolves when water is forced from it. The device was only a toy, and no useful application was made of it.

It was a long time after this, about seventeen hundred years, before any further thought was given to the principle of steam engines. In 1629 an Italian named Branca described an engine that was turned by steam driving directly against paddles on a wheel something like a water wheel. In 1663 a real steam engine was built in England, which was actually used in lifting water from the mines. About seventeen years after this, the first safety valve was invented.

Newcomen's engine. In 1705 Thomas Newcomen constructed a steam engine that was a great improvement on anything that had so far been made. It consisted of a steam boiler and a cylinder in which moved a piston head. The steam forced this head to one end of the cylinder; and then a spray of cold water was led into the cylinder through turning a valve by hand. By the condensation of the steam a vacuum was formed, and the pressure of the air forced the piston head back. Thus the pressure of the steam forced the piston head in one direction, and the weight of the air forced it back. It was necessary for someone to watch this machine and to turn the valves at the end of every stroke. It has sometimes been called an atmospheric engine.

Work of James Watt. The next great improvement was made by James Watt during the latter half of the eighteenth century. He invented a device by which the motion of the engine adjusted valves automatically in such a way that the steam was taken in turn to each end of the cylinder, so that the piston head was moved in both directions by steam pressure, and not in one direction only, as in the Newcomen engine. The steam engine of today is in principle essentially the same as the one invented by James Watt, except that there is now being used for some purposes a different type of engine, called the turbine. However, in the locomotive the Watt type of engine is still used.

First locomotive. The first successful locomotive was invented by an Englishman named George Stephenson. In 1814 he made a successful trip hauling coal cars at the rate of four miles per hour. The first commercial railroad to carry passengers and freight was built between Stockton and Darlington, England; and on the day of its opening, in 1825, the engine was driven at the rate of fifteen miles an hour. From this date, the future of the locomotive was assured.

The locomotive was first used in this country in 1829. From that time railroads developed very rapidly in the United States, many miles being built each year. In 1849 the first continuous line between New York and Boston was completed. In 1869 the first line connecting the Atlantic coast and the Pacific was finished, and now the railroads form a network over the whole country.

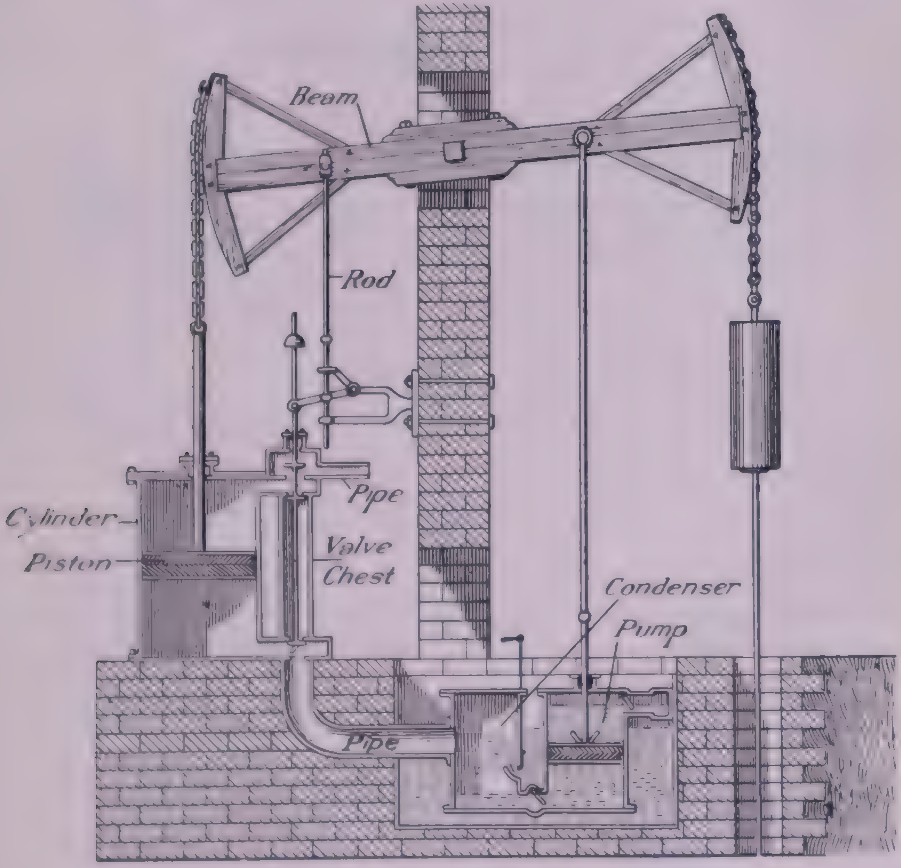

Fig. 81. — Watt engine

In 1923 there were 250,000 miles of railroad in this country, or enough to reach to the moon. In the course of the same year

1,000,000,000 passengers were carried, and 1,387,000,000 tons of freight.

For short distances a speed of 120 miles per hour has been maintained; and a distance of 400 miles has been covered at the rate of more than 60 miles per hour.

Having learned something about the important part that the locomotive plays in everyday life and something of its history, let us now study a modern locomotive to see how it is built and how it works.

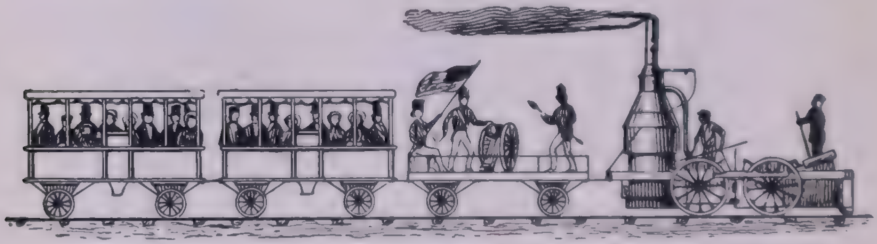

Fig. 82. — First locomotive in the United States

PARTS OF A LOCOMOTIVE

The locomotive consists of three essential parts: first, the fire box and boiler that generate steam; second, the cylinders and their valve gear that use the steam; and third, the wheels on which the locomotive moves.

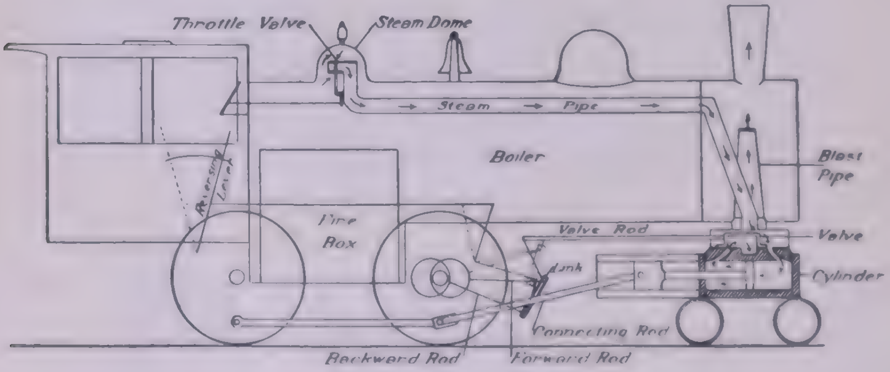

Fig. 83. — Parts of a locomotive

Fire box and boiler. The purpose of the fire box and boiler is to convert large amounts of water into steam in a short time. In order to accomplish this purpose there must be a large amount of heating surface, with heat on one side and water on the other, so arranged that large quantities of water will be in contact with the heated surfaces. There is a direct heating surface on the boiler immediately over and around the fire box; and in addition to this there is the indirect heating surface consisting of the inner surfaces of small tubes about two inches in diameter, which carry off the heated gases from the fire box to the smokestack. About two hundred of these tubes run though the boiler and are surrounded with water. By means of these tubes a heating surface of twenty-five hundred square feet may be obtained, which is equal to the area of a space fifty feet square.

Water gauge. The boiler has attached to it a water gauge, a steam gauge, a safety valve, and an injector. The water gauge is a glass tube so placed on the outside of the boiler that the height of water in the boiler may be determined by looking at this gauge.

Steam gauge. The steam gauge is a device for showing the pressure of the steam in pounds per square inch. It is so arranged that, as the pressure increases, a hand on a dial rotates, much like the hands on a clock; and the pressure is read from the figure to which the hand points.

Safety valve. The safety valve is a device for allowing the steam to escape when a certain pressure is reached, so as to prevent the possibility of an explosion due to overpressure occurring in the boiler. This valve fits into a hole in the boiler; it consists of a tight-fitting plug which is kept in place by a spring. The tension of the spring can be so adjusted as to allow the steam to escape at any desired pressure.

The injector is a device which fills the boiler with water; this is operated by steam pressure.

Fuels. Coal is the fuel generally used. The draft is increased by allowing the exhaust steam to create a partial vacuum in the smoke box as it discharges from the exhaust nozzle, which opens upward toward the smokestack. As a result, air is drawn in through the tubes and fire box, thus making a draft. Some engines are built to use liquid oil instead of coal as a fuel. The oil is forced in the form of a fine spray into the fire box, where it burns quickly.

Cylinder and valves. The parts so far described are used to convert water into steam. The rest of the engine converts the energy of the steam into the motion of the wheels. The steam is led from the boiler into the steam chest *S* (figure 84). From here two openings *p* and *p'*, called ports, lead to the cylinder *C*. Over these openings is the slide valve *V*, with its under surface hollowed out. This valve is connected with an eccentric. In the cylinder is a piston connected on the outside by means of a connecting rod with the drivewheel of the locomotive.

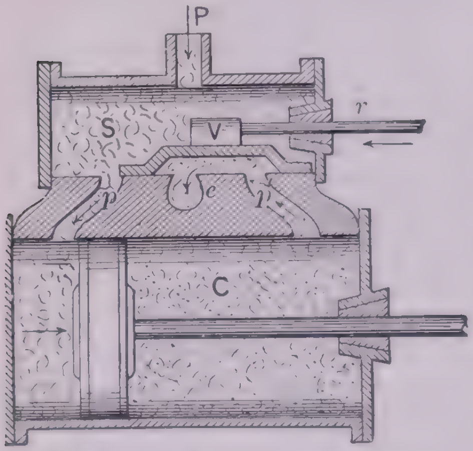

Fig. 84. — Cylinder and steam chest of steam engine

When the steam enters the chest *S*, it passes through *p* and enters the cylinder *C*, pushing the piston to the other end of the cylinder, the steam in this end passing out through *p'* to the exhaust *e* and then to the outside. This motion of the piston turns the wheel, which moves the eccentric, and this in turn moves the valve *V* in such a way that the port *p* is closed and the port *p'* is opened. Thus the steam enters through this opening and pushes the piston back, and the steam in the other end of the cylinder is forced out through the opening *p*.

and then through the exhaust *e* to the outside.

Eccentric. The eccentric consists of a circular plate mounted on the crank shaft. The opening in this plate is not at the center but at one side, so that as the shaft revolves, it gives a slight motion to the eccentric rod, similar to that given by a small crank, and this rod in turn moves the slide valve. These parts are so adjusted that the slide valve covers and uncovers the openings at just the right time to allow the steam to enter each in turn. Two eccentrics are provided for each valve — one for the forward motion when the locomotive is going ahead, and another for the backward motion when the locomotive is going backward.

Link. One very important part of the machinery is the link (see figure 83), which consists of a curved piece of steel, the ends of which are connected with the eccentric rods. This serves two important uses — it enables the engineer to reverse the engine and also to control the amount of steam that enters the cylinder.

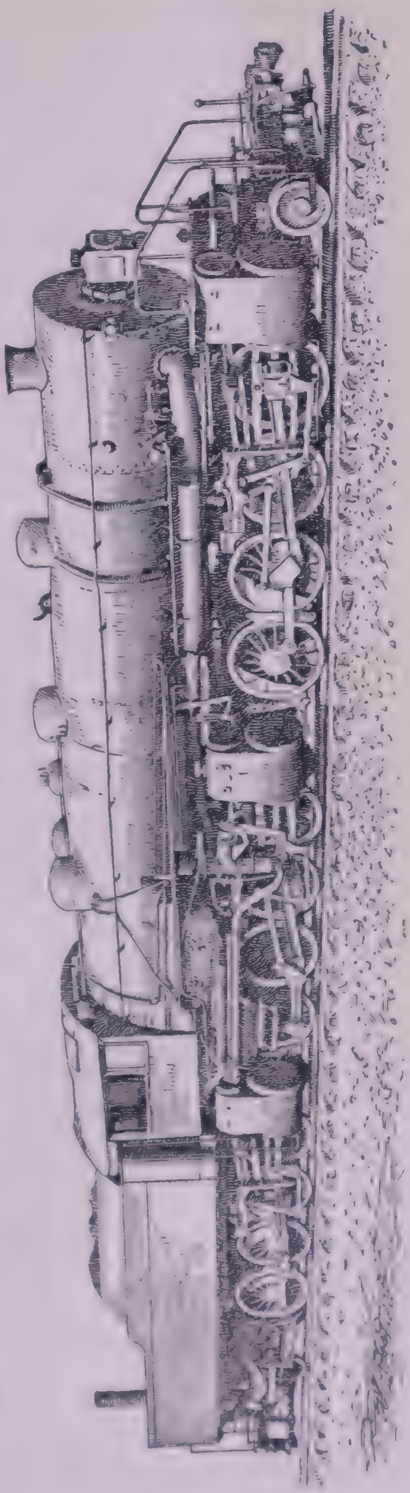

Fig. 85. — A big locomotive

When the engineer wishes to reverse the engine, he throws over a lever which is connected with the link, and this moves the slide valve in such a way that its position is quickly changed, and as a result the steam enters the opposite end of the cylinder, thus forcing the piston to move in the other direction.

Another purpose served by the link is to enable the engineer to regulate the amount of steam that is admitted to the cylinder. When the train is starting, a large amount of power is needed; and steam is admitted afterward for a shorter and shorter portion of the stroke, until the engine is under full headway, at which time only a small amount of steam is used. When the lever is set in the center, no steam at all is admitted to the cylinder; the locomotive then continues to run of itself.

Fig. 86. — Thirty years in locomotive building

The amount of steam admitted to the chest is controlled by the throttle. The most common method of controlling the motion of the link is by means of a lever in the cab, which is worked by hand and is held in place by means of a spring clip fitting into notches In some locomotives a wheel and screw gear is used in place of the lever. In very large locomotives the reversing gear is operated by means of compressed air.

Driving wheels. The motion of the piston rod is communicated by means of heavy driving rods to the large driving wheels, varying from five to ten feet in diameter. In the first locomotives built, a single pair of drivers was used; in later types two and even three driving wheels are used on each side, these being joined by means of side rods so that they turn together. Since the use of several wheels gives more points of contact with the rail, there is less slipping when the train starts, and hence better time can be made when there are frequent stopping places.

When the piston rod is in line with the center of the driving wheel, it has no driving force and is said to be at dead center. The wheels on the two sides of the locomotive are so arranged that when those on one side are at dead center, those on the other side receive the maximum driving power of the piston.

DEMONSTRATION 36

Purpose. To study the parts of a steam engine.

Apparatus. Toy engine or model of steam engine.

Directions. Operate the model and notice carefully how each part works. Make a drawing and label the parts. By means of arrows show the path of steam. Explain the use of each part.

PROVISIONS FOR SAFETY

Brakes. Modern trains are supplied with powerful brakes, which make it possible to stop the trains quickly. One of the most common types is the Westinghouse brake, which is worked by compressed air. On the engine is a tank kept filled with compressed air under high pressure. Under each car is a smaller tank connected by a pipe with the main tank in the engine. Connected with the tank on each car is a cylinder provided with a piston which connects with the brake rigging, which in turn operates the brake shoes on the wheels. The engineer is able to control the working of all the brakes, and by turning a cock he causes the compressed air to enter each cylinder, thus pushing out the piston which sets the brakes on each car.

Railway signals. In order to lessen the possibility of accidents, various systems of signals are used so that the engineer may know whether any other trains are near. The railroad tracks are divided into blocks, or sections, a few miles in length. At the beginning of each block are signals to indicate whether any train is in that block. No train is supposed to enter a block till the previous train has left. Semaphores, or pointed arms, are attached to posts by the side of the track, and by their position they indicate whether a train is in the block. These semaphores may be operated by signalmen, or automatically by electricity. The weight of the train on the rails closes a circuit, which operates the signal. On a double-track road, the engineer is concerned only with trains going in his direction; on the single-track road, he is concerned also with trains coming from the opposite direction.

Train dispatcher. The trains are controlled by a train dispatcher, who has telegraph connections with every railroad station. He keeps a careful record of the position of every train. The telegrapher at each station informs the dispatcher when each train leaves his station. Ordinarily the trains run on scheduled time, and each engineer and conductor knows where he is expected to be at any given time and what right of the road he has. But when a train becomes delayed, the schedule is interfered with; and the trains are then run by special word from the dispatcher, who sees that proper places are assigned for meeting other trains with as little danger and loss of time as possible. These orders for the trainmen are telegraphed to the operators at the stations and given by them to the conductor.

OTHER USES OF THE STEAM ENGINE

We have referred to one common application of the steam engine — in the locomotive. We are also indebted to the steam engine for many other services. The great dynamo that generates electricity for lighting our homes and streets and for running the electric cars is usually turned by a steam engine. Other applications of the steam engine are seen in factories where it is used to run the machinery. The great majority of the common things that enter into our everyday life are factory made. Our clothing is made from thread woven or knit in mills. Many of our foods have passed through some process in a factory. The shingles and boards in the houses that furnish us shelter have been prepared in mills run by steam engines. The furnaces and stoves that warm our homes have come from the factory. The furniture in our homes, the rugs on the floors, and the curtains at the windows have, somewhere in their process of manufacture, been fashioned by machinery run by steam engines. The books and magazines that we read and the paper that comes to our doors daily have been printed on presses operated by the steam engine.

In some cases, waterfalls and electricity furnish the power to run the machines of the factory; in many cases, however, the electricity is generated by steam power; and the steam engine still remains the most common source of power used in factories.

OUTLINE SUMMARY

The Locomotive

I. Uses of the locomotive
  1. Brings necessities of life
  2. Suburban homes
  3. Growth of the United States
  4. Means of travel

II. History of the steam engine and the locomotive
  1. Early inventions
  2. Newcomen's engine
  3. Work of James Watt
  4. First locomotive

III. Parts of a locomotive
    1. Fire box and boiler
        a. Water gauge
        b. Steam gauge
        c. Safety valve
        d. Fuels
    2. Cylinder and valves
        a. Eccentric
        b. Link
    3. Driving wheels

IV. Provisions for safety
    1. Brakes
    2. Railway signals
    3. Train dispatcher

V. Other uses of the steam engine

QUESTIONS FOR CLASS DISCUSSION

1. What do you consider the most important use of the locomotive?
2. Compare the methods of traveling from Boston to Washington used one hundred years ago with the methods used now.
3. What was Watt's contribution to the steam engine?
4. What are the methods used for generating steam in a locomotive?
5. How is the energy of the steam converted into the motion of the wheels?
6. What are the uses of the link?
7. What precautions are taken to prevent accidents on railroads?

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CHAPTER XVI

THE ELECTRIC TROLLEY CAR

What part does electricity play in the running of the trolley car?

USES OF ELECTRIC TROLLEY CAR

One of the recent developments in means of travel is the electric trolley car, which has grown rapidly in popularity. Almost every large city now has its system of electric cars; and in the more thickly settled portions of the country a network of these lines connects the larger cities. The electric car is taking the place, to some extent, of the steam cars. It has one great advantage over the steam cars in that no special roadbed need be constructed, as the rails can be laid up hill and down, on roads already constructed or across country. As a result the cost of construction is very much less. Other advantages are: no smoke, gas, or cinders; high overload capacity for, say, a half hour; high acceleration; and flexibility of control.

In some localities interurban lines are being constructed through regions of beautiful scenery, and the trolley car is a source of much pleasure during the summer months as well as an important business necessity at all times of the year. Like the railroad, the electric car widens the area about a big city in which business men may live, and thus enables them to find pleasant homes in the suburbs.

HISTORY OF ELECTRIC CARS

Crude forms of electric cars were made many years before they became a practical success. In 1835 Thomas Davenport, of Vermont, constructed a small circular railway at Springfield, Massachusetts, on which he operated a car driven by a motor. This was probably the first electric car ever built. Following this, other inventors at various times made different forms of electric cars. The first practical electric locomotive, made by Doctor Siemens, was exhibited at the Industrial Exposition in Berlin in 1879. It attracted a great deal of attention, and inventors from various parts of the world began to devote more time to perfecting an electric car; from this electric locomotive, then, may be said to date the development of the modern electric car. Improvements in the dynamo and motor have made the perfection of the practical trolley car possible.

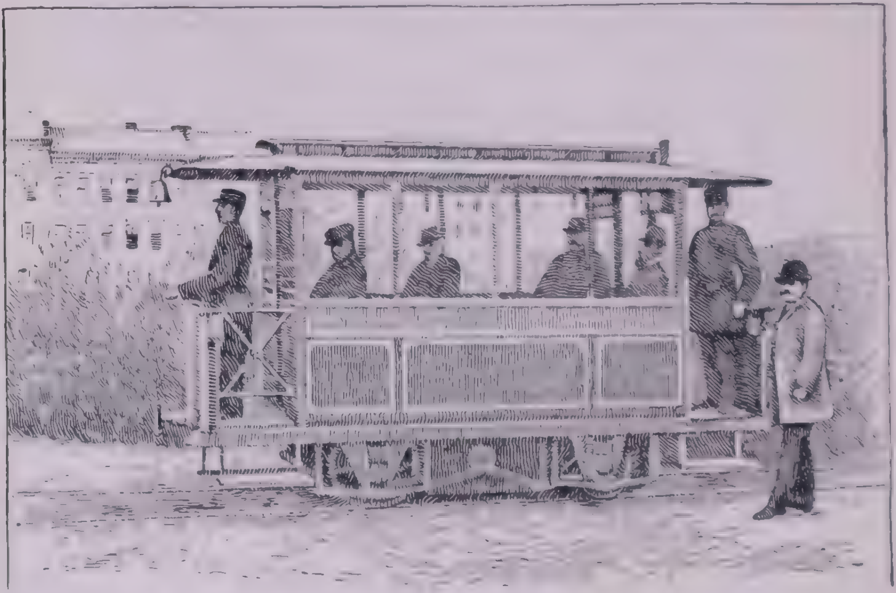

Fig. 87. — The first electric railway in Germany

First electric car. Shortly after this exposition, the first commercial electric railway in the world was constructed in Germany, between Berlin and Lichterfelde, a distance of about a mile and a half. For this railway a horse car was converted into an electric car by mounting a motor between the axles.

Electric cars in America. In this country special attention was given to electric cars by Stephen Field and Thomas A. Edison. In 1881 each constructed a short electric railway — Field in Stockbridge, Mass., and Edison in Menlo Park, N. J. In 1883 an electric railway was constructed at the Chicago Railway Exposition. The electricity was conveyed to the motor by means of a central rail.

The first commercial electric street railway in this country was constructed in 1885 between Baltimore and Hampden, Md., a distance of two miles. Since that time many improvements have been made in the electric car, and it has advanced with rapid strides until now the trolley car is a common sight in all parts of the United States. A few figures will give some idea of this growth. In 1885 there was one electric railway in the United States; in 1890 there were 144; in 1917 there were 44,808 miles of single track, and in 1922 there were 43,933 miles. The above figures show that from 1917 to 1922 there was a slight decrease in the miles of track operated. This decrease was doubtless due to the rise of the bus, which is taking the place of the trolley to some extent.

PARTS OF THE TROLLEY CAR

We may now attempt to understand some of the principles involved in the working of the trolley car. If we take into account all the details, it is a very complicated piece of machinery; but some of the simpler facts regarding it can be easily understood. As electricity is needed to run the trolley car, let us first notice how this electricity is made. Therefore we will start at the power house.

Dynamo. The dynamo is the machine by means of which electricity is generated. It consists of the following parts: electromagnet (field magnet), armature, brushes, and commutator or collecting ring. The armature, which consists of a coil or a series of coils of wire, is placed between the poles of the magnet and so mounted on an axle that it rotates. When the armature revolves between the poles of the magnet, it is cutting across the magnetic lines of force running out from these poles, and as a result an electric current is set up along the wire. By means of proper connections this current may be led out and carried away by wires. Two kinds of currents may be produced by these dynamos: the alternating current and the direct current. In alternating currents the direction in which the electricity is passing changes with each half revolution of the coil of wire. In direct currents the current is passing in the outside circuit in the same direction all the time. In both types of dynamos the current in the coil is alternating, but by means of a commutator it is so changed in direction that it is a direct current outside of the armature; or, if slip rings are employed, the current outside of the armature remains an alternating current.

In accordance with the way in which a current is led through the field magnet, there are three types of dynamos. In the *series-wound* dynamos all of the current produced by the armature passes through the field magnet winding. In the *shunt-wound* dynamo only a part of this current passes through the field magnet coils. The *compound-wound* dynamo has both the series and the shunt connections. This is the type most commonly used, because it possesses certain self-regulating properties.

In order to produce strong currents, very powerful electromagnets are used, with many coils of wire in the armature. It does not matter whether the magnets are stationary and the armature revolves, or the armature is stationary and the magnets revolve. Dynamos of both forms are used.

DEMONSTRATION 37

Purpose. To illustrate the principle of the dynamo.

Apparatus. Galvanometer; bar magnet; primary and secondary coils (the inner one removable); wire.

Directions. 1. Connect a coil of wire with a galvanometer. Thrust a bar magnet into the center of the coil and watch the needle. After the bar comes to rest, is there any current?

2. Remove the magnet and notice the needle.

3. Connect a primary coil of wire with a cell. Thrust this coil into the center of the secondary coil used in the previous experiment. Watch the needle. Remove the coil.

4. Try again, putting an iron core in the primary coil.

5. Under what conditions is a current generated in the secondary coil of wire?

Power to turn dynamos. Some power must be used to turn the dynamos. For this purpose, water wheels, steam engines, and gas engines are used. Water is the cheapest of these and is very widely used. The power plants at Niagara Falls are well known examples of the use of water power. The electricity here generated may be carried many miles to points where it is used. The electric current is taken from Niagara a distance of 154 miles to the city of Syracuse, where it is used to drive the street cars. In other localities it is being carried even longer distances than this. At the present time the most common means used for turning the dynamo is the steam engine. In some places the gas engine is used.

How the current is conducted to the car. From the power house the electricity is conducted by means of wires to the trolley cars. In the system most commonly used, the electricity is conveyed by a wire known as the trolley wire, suspended over the tracks. The electricity passes from this to the car through the trolley pole. Powerful springs at the base of the pole push the pole upward, keeping the trolley wheel in constant contact with the wire. From the trolley pole base the current is conducted to the various parts of the car and returns to the dynamo in the power house by means of the rails on which the car runs.

In order to complete the circuit, the ends of adjacent rails are either connected by wires or else welded. In order to supply enough electricity to all parts of the system, different wires, known as feeders, are run from the main supply of the current and connect with various parts of the system.

Controller. As we watch the motorman running the car, we notice that he controls the car by means of three handles, one for the brakes, and two on a boxlike structure called the controller. When he wishes to start the car, one of the handles is turned, a notch at a time, till a place is reached where it is allowed to remain stationary. When he wishes to stop, the handle is turned back again and the brakes are applied. If he wishes to make the car go backwards, he moves another handle and then turns the first handle as before.

This controller serves three purposes: First, it connects the motor to the line so that the car can be started or stopped; second, it regulates the amount of electricity which passes to the motor, so that the speed of the car can be controlled; and third, it governs the direction in which the car goes, so that it can be made to go either forward or backward.

If the full current were turned into the motor suddenly, it would cause the car to start with an unpleasant jerk and it might injure the motor. In order to avoid this, resistance grids are so connected with the motor that when the handle is turned to the first notch the current passes through both the grids and the motor; and thus the motor at first receives only a limited amount of current at reduced voltage. As the handle is turned still further around, these resistance grids are cut out, till finally the motor receives the full line voltage and runs at full speed.

Circuit breakers. In order to protect the parts of the machinery on the car from being injured by too strong a current, circuit breakers and fuses are provided. These circuit breakers are so arranged that when too strong a current passes through them they automatically open the circuit. Sometimes when riding on the trolley cars one hears a noise like an explosion, which is due to the working of this circuit breaker. If you watch the motorman, you will see that he reaches up and turns back a handle connected with the circuit breaker, thus making a connection again.

Fuses. A fuse serves the same purpose as the circuit breaker. This is composed of certain metals that melt when a strong current passes through them, thus opening the circuit and preventing the current from passing through the remaining portions of the machinery.

Motor. The machine which actually makes the wheels of the car turn is the motor, which is placed under the car and is connected to the axles by means of gearing. The construction of the motor is like that of a dynamo; that is, it is a reversible machine. The same machine can be used for either a dynamo or a motor. If it is turned by some outside power, it generates electricity; if electricity is conducted through it, the parts begin to revolve. As a matter of efficiency, however, it is found better to make machines intended for motors somewhat different from those intended for dynamos.

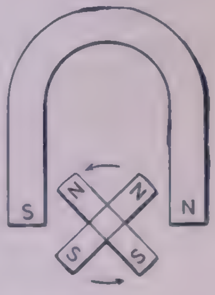

Fig. 88. — Illustrating principle of electric motor.

The motor has the same essential parts as the dynamo — that is, armature, electromagnet, brushes, and commutator or collecting ring. When two magnets are brought together, if the north pole of one is brought near the south pole of the other they will be drawn towards each other (see figure 88). If the two north poles or the two south poles are brought together, they will be pushed apart. This action of magnets may be well illustrated by means of a bar magnet and a compass, which is a magnet mounted so that it can rotate. If the south pole of the magnet is brought near the north pole of the needle, the needle will turn around till its north pole points towards the south pole of the magnet. If the magnet be constantly moved, the needle may be kept in constant motion.

When an electric current is passed through a motor, both the field magnet and the armature become magnets with north and south poles; and on account of the attraction of unlike poles and the repulsion of like poles, the armature is caused to revolve. The motor is so constructed as to make the motion continuous as long as the current passes through. It is connected with the axles of the car by means of reduction gears, and thus the wheels are made to rotate and the car is made to move.

We have the same two types of motors as of dynamos, the direct and the alternating; the former runs on a direct current and the latter on an alternating current. As with the dynamo, so with the motor: the direct current machine has a commutator while the other has not.

Thus the long story that began with the burning of coal in the fire box of an engine at the power house is now completed, when the energy generated by the burning is made to move the wheels of a trolley car miles away.

DEMONSTRATION 38

Purpose. To see how the motor works.

Apparatus. Two bar magnets; wire; two long nails; small motor; two cells.

Directions. 1. In order to understand the principles involved in the motor, we will first study the action of two bar magnets towards each other. Make a stirrup of a piece of wire and suspend a bar magnet in this by means of a string. Bring the north pole of the other magnet near the north pole of the suspended magnet. Bring it near the south end. What difference in action do you note? Bring the south end of the free magnet near the south end of the suspended magnet and then near the north end. What is the law governing the action of magnets towards each other?

2. Make two electromagnets by winding six or seven feet of insulated

wire around each of two long nails. Connect each electromagnet with a cell. Suspend one of them as was done with the magnet in the previous experiment. Bring the ends of the other electromagnet in turn near the ends of the suspended magnet. What happens?

3. Connect a small motor with a cell and notice how the parts work. How does the previous experiment help you to understand what takes place?

Brakes. While some of the smaller cars are stopped by means of hand brakes, most of the larger cars are fitted with brakes operated by compressed air and similar to those used on railway trains. The air is compressed by means of a motor which works automatically, always keeping the pressure in the reservoir tank up to a certain point. We often hear this machine running while we are riding on the trolley car; it suddenly stops when a certain air pressure has been reached, and then starts again when the motorman has used the brakes and the pressure has been lessened to a certain point.

Lighting and heating. The cars are lighted and usually heated by current taken from the trolley wire. The electric heaters are usually placed at intervals under the seats on both sides of the car.

THE ELECTRIC LOCOMOTIVE

There are conditions in which the smoke of the ordinary locomotive is very offensive and in fact unsafe. To insure safety in tunnels and to avoid the danger of smoke and sparks elsewhere, the electric locomotive is now to some extent taking the place of the steam locomotive. Some railroads are extending its use to great sections of their lines. The electric locomotive may also be made of much smaller weight than the steam locomotive, but it must be heavy enough so that the drivers will not slip if equally heavy trains are hauled. It is run by motors similar to the ordinary trolley car, but more powerful; and a single engine may draw a whole train of passenger or freight cars.

OUTLINE SUMMARY

The Electric Trolley Car

I. Use of the electric trolley

II. History of electric cars
  1. First electric car
  2. Electric cars in America

III. Parts of the trolley car
  1. Dynamo
    a. Power to turn dynamos
    b. How the current is conducted to the car
  2. Controller
  3. Circuit breakers
  4. Fuses
  5. Motor
  6. Brakes
  7. Lighting and heating

IV. The electric locomotive

QUESTIONS FOR CLASS DISCUSSION

1. What advantages has the trolley car over the locomotive?

2. What parts do the dynamo and the motor play in running the trolley car?

3. In what ways are the dynamo and the motor alike?

4. How does the motorman control his car?

5. What provision is made in the electric cars for protection from accidents?

6. How is the electricity produced that runs the cars?

7. How does the motor change electric power into mechanical power?

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CHAPTER XVII

THE AUTOMOBILE

What should a person know about an automobile in order to give it proper care and run it without accidents?

Uses of Automobiles

Automobiles now seem to be used for almost every purpose that any type of vehicle has ever served. Within a comparatively brief period of time the automobile has come to have a profound influence on our lives. Starting about thirty years ago as a curiosity, it has come into almost universal use for both pleasure and business. In recent years it has been competing with railroads and trolley lines as a means of transporting freight and passengers. In the more thickly settled parts of the country, automobile trucks are carrying large amounts of merchandise formerly sent by freight or express. In 1924 there were nearly two million motor trucks registered. Motor buses are now an important part of our national system of transporting passengers. In the single state of Minnesota, motor buses carried nearly nine million passengers during the year 1923. In the year 1924 ten thousand motor buses were made in this country.

Answers to a questionnaire received from one thousand automobile owners in ten states give the following figures on the various uses to which autos are put:

Purpose	Per Cent	Purpose	Per Cent
Evening driving	68	Picnics	52
Shopping	58	Long distance touring	51
Driving to work	52	In business	46
Driving to church	52	Motor camping	20

The fact that the total amounts to more than 100 per cent is explained by saying that most autos are used for more than one purpose.

HISTORY OF THE AUTOMOBILE

The first carriage to be propelled by an engine was built in 1769 by a Frenchman named Cugnot. It was a very clumsy affair mounted on three wheels. It traveled only three or four miles an hour, it was obliged to stop every ten minutes to get up steam, and it could carry only three persons. Compare this with our modern automobile!

The next steam carriage was made in England in 1801 by Richard Trevithick. The use of this carriage so frightened the horses that a law was passed requiring a man to walk ahead of the steam carriage with a red flag to give warning of its approach. Steam carriages later were prohibited from using the highways altogether, because they interfered with the horse traffic. It was not until 1896 that this "Red Flag Act" was repealed.

In the year 1895 when one of the first automobiles was passing along Michigan Avenue, in Chicago, the driver was stopped by a policeman and told that horseless carriages were not permitted on the streets.

In Boston the first motor cars were not allowed to use the streets at all until nine o'clock at night.

In 1896 the automobile was exhibited as an attraction in one of the side shows of Barnum and Bailey's circus. An admission fee of ten cents was charged to see a crude self-propelled vehicle travel around a circular track.

No great progress was made in the development of power-propelled vehicles till after 1885, at which time Gottlieb Daimler invented the high-speed gas engine. And it was not until the beginning of the present century that the automobile began to show rapid development. No machinery or invention for travel has ever made such rapid strides as has the automobile during the past twenty years. In 1895 the first automobile race was held in this country. The winning car, which was driven by a four horsepower engine, traveled at the rate of 7½ miles an hour. Twenty-nine years later, in 1924, racing cars had reached a speed of 168 miles per hour.

In the past seven years the number of cars in the United States has more than trebled. The following table gives the facts about the change in this period:

YEAR	NUMBER OF CARS MADE	NUMBER OF CARS IN UNITED STATES	NUMBER OF PERSONS TO ONE CAR
1917	2,000,000 (nearly)	5,100,000	20
1924	3,650,000	17,700,000	6½

The entire population of the United States could be carried at one time in these 17,700,000 autos. A little more than one fourth of these autos are on farms. There are five states each of which has more than a million cars. In California there is one car to every three persons. Eighty-seven per cent of all the cars registered in the world are in the United States.

In the year 1924 six billion gallons of gasoline were used by motor vehicles — an average of 340 gallons to a car, or nearly a gallon a day. Assuming that the average car runs fifteen miles on a gallon of gasoline, the average distance traveled in a year by a car was five thousand miles, a distance greater than the width of the United States from coast to coast.

AUTOMOBILE ACCIDENTS

While on the whole the introduction of the automobile has been a great advantage to man, there has been a very unfortunate accompaniment to the great increase in the number of automobiles — namely, the large number of deaths and accidents due to them. So serious has this problem become that a conference on street and highway safety met in Washington in December, 1924, to consider the matter of accidents and their prevention.

The following figures are taken from the report of the committee on statistics.

Extent of accidents. In the year 1923, the people killed in automobile accidents numbered 16,452. And this figure does not represent the entire toll, because it does not include the train grade-crossing accidents and the street car accidents that are due to automobile traffic. The committee estimates that if these be added to the figures given above, the number of deaths in 1923 due to motor traffic was 19,227. The figures for 1924, as compared with those for 1923, show an increase of 5.5 per cent, making the total number of deaths 20,284.

In 1923 there were as many deaths from automobile accidents as from diphtheria, more than from typhoid fever and measles combined, and more than from whooping cough, measles, scarlet fever, and smallpox combined.

Thirty per cent of all fatal automobile accidents happen to children of school age and under; or in other words, six thousand children of school age and under were killed in motor accidents in the year 1924.

The number of deaths has risen from four thousand in 1913 to sixteen thousand in 1923, or it has quadrupled in ten years. Since 1917 the death rate per hundred thousand has risen from 9.1 to 14.9. On the other hand, the number of deaths per thousand cars has decreased from two in 1916 to one in 1924. In other words, in 1916 there was one death to every five hundred cars, while in 1924 there was one death to every thousand cars.

While the death rate per thousand cars has been decreasing throughout the whole country, the total number of accidents per thousand cars in the state of Connecticut has been increasing. It increased from twenty-four accidents per thousand cars in 1918 to eighty-three accidents in 1923. Or, to put it in another way, in 1918 there was one accident to every forty-two cars, while in 1923 there was one accident to every twelve cars. The rate for Vermont for 1923 was the same.

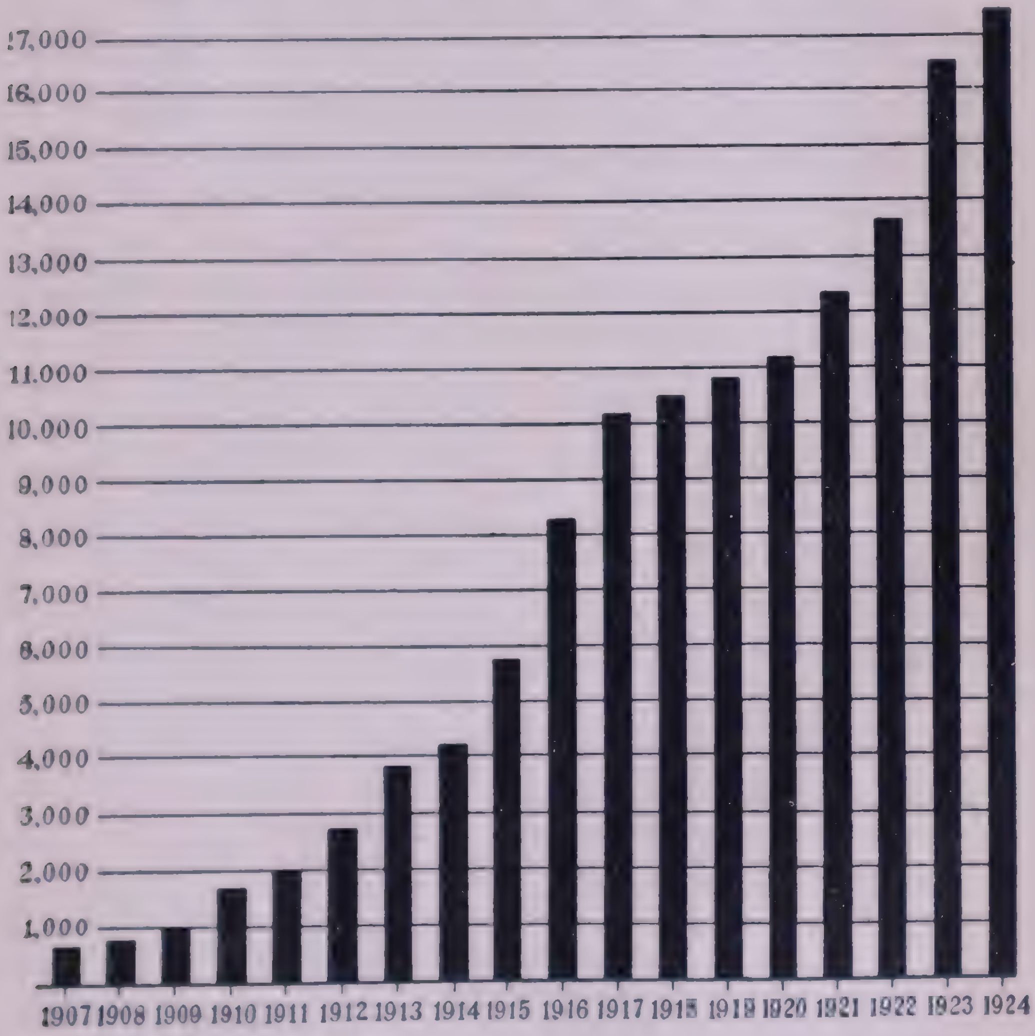

Fig. 89. — Number of deaths from automobile accidents in the United States

The studies of the committee led them to conclude that for every death there were thirty serious non-fatal injuries. At this rate the total number of people injured in 1923 was about 575,000. This figure, large as it is, does not represent the total number of accidents, but only those in which people were injured. There were many more accidents in which there was property damage without personal injury. Experts who have been giving the matter careful attention estimate the total number of accidents to be between three million and four million.

Property loss. In addition to the lives lost and the people injured, there is also a great economic loss in dollars, due to all the factors involved in accidents, such as property damage, the hospital expenses of the injured, the value of their lost time, the loss caused by traffic delays, and still other factors. Those who have studied this question estimate that the annual loss may range between $600,000,000 and $1,000,000,000.

Causes. The report already mentioned presented records from six different sources representing every part of the United States and gave the figures for the causes of nearly eight thousand accidents. The average results from all these sources combined are as follows:

CHIEFLY TO BLAME FOR ACCIDENTS

Driver	43 per cent	Other people	11 per cent
Pedestrian	33 per cent	Defective equipment	7 per cent

The two significant facts that this table shows are: first, that the human factor is the chief cause of accidents, since very few are due to defective equipment; and second, that the responsibility for the accidents is about equally divided between the driver and other people, of whom pedestrians make up by far the larger portion.

In some of these reports the particular kind of carelessness responsible for accidents was given. These reports when averaged together give the following figures:

Fault of Operator	Per Cent	Fault of Pedestrian	Per Cent
Too fast for conditions	16	Carelessness of adults in crossing streets . .	21
Violating rules of road	11	Children crossing streets or playing in streets	12
Inattention	9	Stepping from behind vehicle	7
Intoxication . . .	5	Pedestrian confused .	3
Inexperience . . .	3	Children coasting . .	2
Confusion	3	Intoxication . . .	1

Remedies. In order to apply remedies we have only to examine the causes and seek to remove them. Among drivers the chief kinds of carelessness are: driving too fast for conditions (speeding); violating the rules of the road; and inattention.

Precautions for drivers. Since the speed at which a person may drive with safety depends on the conditions, no general rule can be given that will cover all cases. It is self-evident that at intersections, in crowded traffic, and on curves the speed should be reduced. Most states have laws regulating the speed that may be maintained under the varying conditions. The general rule for the driver is that he should never drive so fast that the vehicle is out of his control. The important point for the driver to consider is the shortest distance in which his car can be stopped in case of necessity.

The committee on traffic control at the conference made two recommendations: first, that no town should establish a limit lower than fifteen miles per hour; and second, that there should be established a limit beyond which there is presumption of reckless driving. The committee would place this limit at thirty-five miles per hour on the open highway.

Violation of the rules of the road, or failure to give right of way, is the second most common cause of accidents. Prevention of accidents from this cause means that every driver should give heed to the rules of the road, especially to the one regarding intersections of streets, which gives the right of way to the vehicle approaching from the right.

In discussing inattention as a cause of carelessness, we may note that a score of matters may distract the driver's attention, such as fixing the windshield, lowering a window, or shutting a door. The remedy is evident: The driver should give his *undivided* attention to the running of the car.

In the case of children, whether simply crossing the street or playing in the street, the driver should take the larger share of responsibility, because the children are not to be blamed for doing some things which in an adult would be an indication of extreme carelessness. Children are children.

Rules for driving. Observance of the following rules would help to reduce the number of accidents:

1. Slow down at street intersections.

2. At street intersections give the right of way to the car approaching from the right.

3. On curves, slow down and keep to the right of the road.

4. Never pass another car on a curve or at a street intersection.

5. When turning to the left, give a hand signal.

6. Near school buildings be extra watchful on account of the children.

7. Before crossing railroad tracks, change from high speed into intermediate. This precaution would produce two results, each making for greater safety: First, it would compel the driver to slow down; and second, it would lessen the possibility that the engine might stall while the automobile was on the tracks.

Precautions for pedestrians. We have seen that the chief ways in which pedestrians are to blame are: crossing streets carelessly, stepping from behind other vehicles, and playing in the streets. The precautions to be observed on busy streets by pedestrians may be summarized as follows (and since all drivers are also pedestrians, these apply to all):

1. Cross streets only at the intersections, never in the middle of a block.
2. Never cross a street intersection diagonally (jay-walking).
3. When starting to cross a street, look to the left; on reaching the center of the street, look to the right.
4. Do not step from behind a vehicle and start to cross a street.

In order to lessen the accidents due to defects in the car — as in the brakes, the steering gear, or the lights — the owner should give his car frequent inspection himself, or see that it is done by someone else.

Control by law. Besides educating the public to the steps necessary to reduce auto accidents, certain laws and regulations must be passed and enforced. The report of the First National Conference on Street and Highway Safety contains the following recommendation: "No unlicensed person should be permitted to operate a motor vehicle." Before a license is granted, the applicant should be examined to test his knowledge of the driving laws of the state, his ability to drive carefully, his general intelligence, and his ability to read, and to determine whether he has any physical defects, such as those of the eye or the ear, that would seriously interfere with his driving a car.

Severe penalties should be enforced against drivers who are unusually careless, such as those who drive recklessly or drive while intoxicated. These penalties may consist of fines, imprisonment, or suspension or revocation of a license to drive a car.

Other means of improvement look toward the betterment of roads with special reference to removing dangerous conditions, or toward warning motorists of dangerous conditions by means of signs. Special attention should be paid to railroad crossings.

In crowded cities the traffic problem may be partly solved by traffic officers stationed at busy intersections or by automatic signals.

THE BODY

While there are many makes of cars and while they differ in many details, yet they agree in that they all possess certain fundamental parts. These parts of an automobile may be grouped for convenience into the following six divisions: (1) the body, (2) the running gear, (3) the power plant, (4) the transmission system, (5) the electric system, and (6) the control apparatus.

There are two types of motor cars — passenger cars and commercial cars — named according to the use each type serves. Among the most common types of bodies of passenger cars are the following: roadster, touring, coupé, sedan, limousine, and coach. In recent years the closed types have been growing in popularity. In order to get some of the advantages of the closed car in the open type, glass curtains may be used, and sometimes winter tops are put on.

THE RUNNING GEAR

Axles and wheels. The running gear includes axles, wheels, springs, and frame. The front axle is attached solidly to the frame and not pivoted at the center like the axle of a carriage. At either end of this main axle the wheel is mounted on a short spindle and pivoted in such a way that it can be moved so as to turn the vehicle in any desired direction. The spindles carrying the wheels are so connected by a tiebar that both front wheels move together. The motion of these wheels is con-

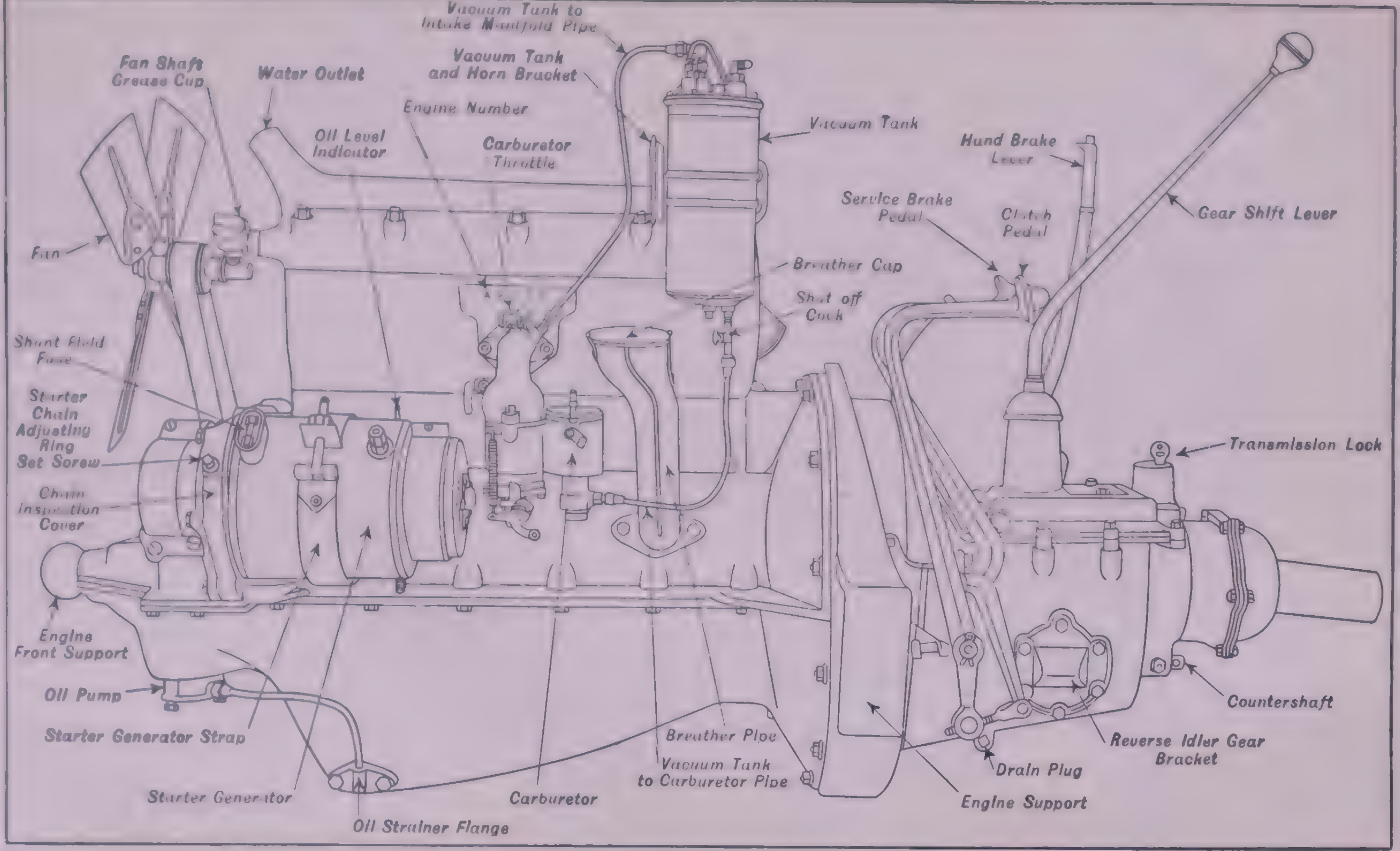

Fig. 90. — An automobile power plant

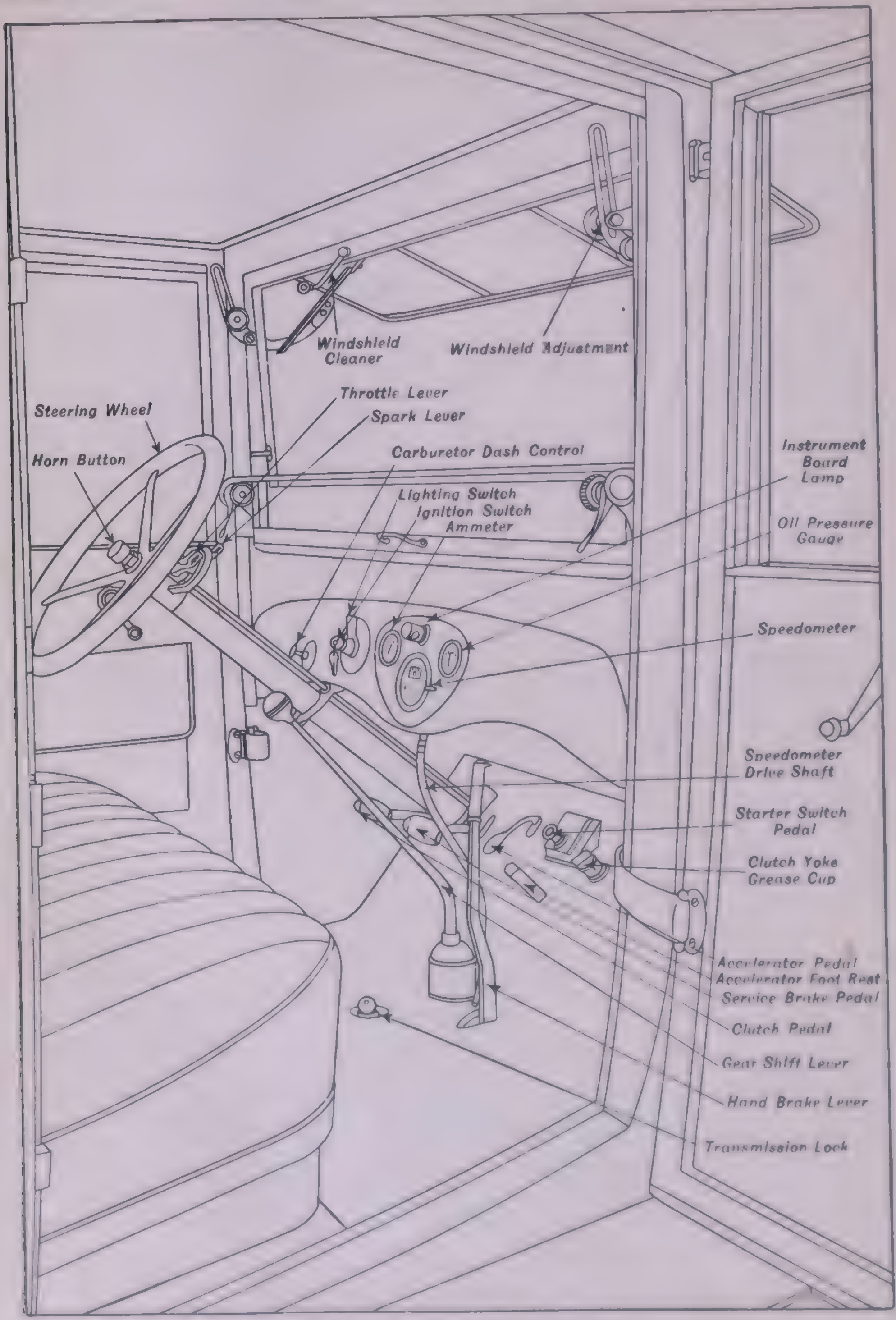

Fig. 91. — Control instruments

trolled by a steering wheel, which turns a lever connected with the spindle on which the wheel revolves (see figure 92). The rear axle not only helps to support the weight of the car, but it is here that the power of the engine is transmitted to the wheels so as to move the car (see figure 93).

Wheels may be divided into three classes: wood, wire, and disk wheels, the disk type being made of either wood or metal.

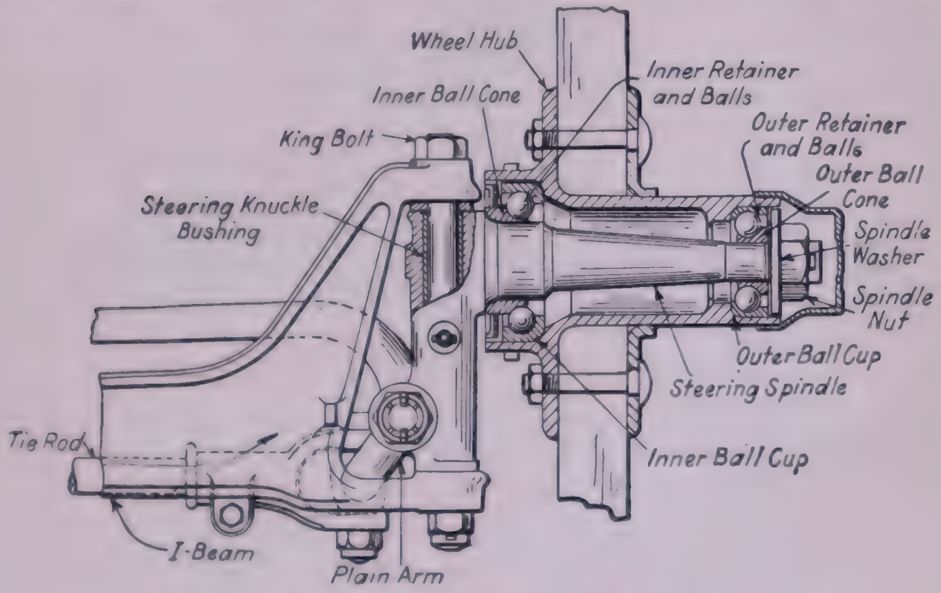

Fig. 92. — Front wheel bearings

Tires. On large motor vehicles used for carrying heavy loads, solid rubber tires are frequently used; for the ordinary car, pneumatic tires are used. The pneumatic tire includes a tough outer casing, called the shoe, which comes in contact with the road; inside of this and protected by it from wear is a tube of rubber, called the inner tube, which is air-tight. By means of an air pump this is filled with air under pressure. In order to prevent skidding, the outer casing is made with a roughened surface; and in wet weather, chains are attached to the tires. To reduce friction the wheels are mounted on the axles by means of ball or roller bearings.

An improvement in tires that has been widely adopted is the balloon tire. This is of extra large size and so made that it can be used with low air pressure. Among its advantages are ease in riding and reduced wear on the car.

Frame and springs. The frame supports most of the weight of the car, connects the axles, and carries the springs. The frame is usually made of steel; and the lightness and strength of the modern automobile are due largely to the new varieties of steel that have been introduced in recent years. The frame is supported on the axles by means of springs.

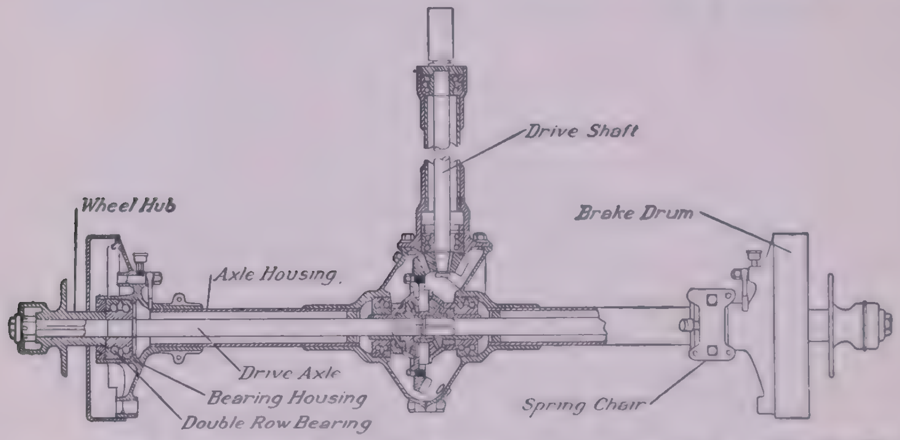

Fig. 93. — **Semi-floating automobile rear axle construction, with shafts and gearing mounted on double row ball bearings**

THE POWER PLANT

The power plant consists of the following parts: internal combustion engine, a carburetion system, a lubrication system, a cooling system, and an ignition system.

Internal combustion engine. The term "internal combustion" is applied to this engine because the fuel is burned inside the cylinder. The explosion thus caused forces back the piston. Before entering the cylinder, the gasoline is vaporized or atomized and is mixed with air in the carburetor. The mixture is set on fire by means of an electric spark.

How it works. The common internal combustion engine is spoken of as a four-cycle engine, as there are four distinct steps in the action of the piston, going to make one complete cycle (two revolutions of the crank shaft). The first downward stroke of the piston sucks the mixture of air and gasoline from the carburetor into the cylinder. The second upward stroke compresses this mixture. At the beginning of the third downward stroke, the explosion of the mixture takes place and the piston is forced back. On the fourth upward stroke the burned gases are forced out of the cylinder through a valve. These strokes are called respectively suction, compression, combustion, and exhaust (see figures 95 to 98).

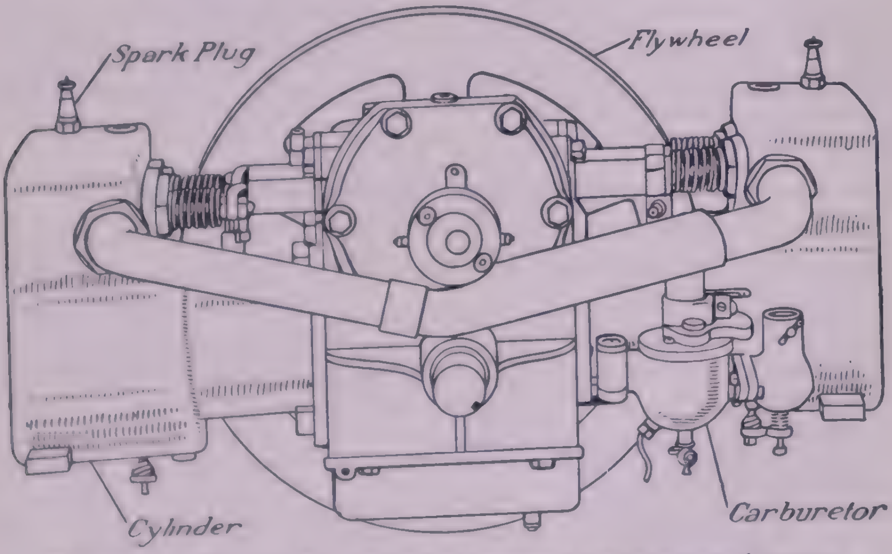

Fig. 94. — Simple two-cylinder opposed water-cooled motor

Only once in four strokes, therefore, is the motive power applied to the piston. In order to keep the piston running during the other three strokes, a heavy flywheel is provided, which keeps the crank shaft rotating until the next explosion.

In order to give a more even application of power, automobiles are now furnished with engines of four, six, eight, or even more cylinders. A four-cylinder engine would be so arranged that the driving gear would receive a push four times as frequently as it would from an engine of one cylinder.

Starting. In order to start the engine, some power must be used to move the piston through a few strokes till an explosion occurs. In some cars this is done by hand, by means of a crank attached to the front of the car. Other cars have electric starters, in which the power to start the piston is furnished by a motor driven by electricity from a storage battery. This starter is controlled by pressing a button or a lever.

Comparison with steam engine. The gas engine differs from the steam engine in a number of ways, as shown in the following table:

GAS ENGINE	STEAM ENGINE
1. Fuel burned inside of cylinder	1. Fuel burned in fire box
2. Propelling force applied only once in four strokes	2. Propelling force applied at every stroke
3. Propelling force applied only on one side of piston	3. Propelling force applied alternately on both sides of piston
4. To start engine, crank shaft must first be rotated by some external means	4. Starts at once as soon as steam is admitted to cylinder
5. Load applied gradually by means of a clutch	5. Can begin to do work at once

Energy. In our studies so far we have learned of many useful machines, such as the electric motor, the steam engine, and the gasoline engine. We may now stop to inquire regarding the source of the energy that runs these machines. In the realm of physics the word "energy" is used in a very specific sense, to mean the ability to do work. Energy may show itself in many forms, such as electrical, chemical, and mechanical; and one form may be changed into another. Let us see if we can trace back the energy of the steam engine to its original source. The immediate source is the burning of the coal in the fire box. This coal was formed from plants that grew many, many years ago; and the source of the energy stored up in these plants was

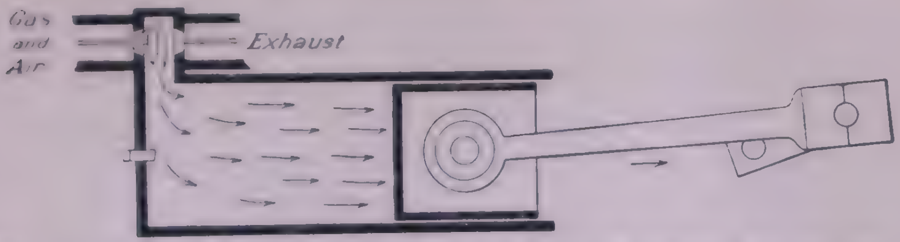

Fig. 95. — First stroke (suction) — gas and air admitted to cylinder

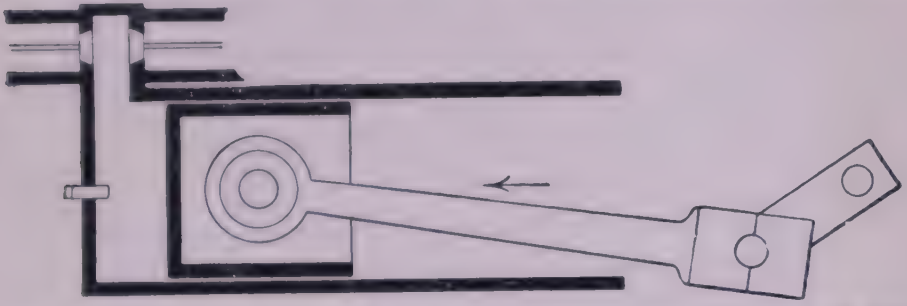

Fig. 96. — Second stroke (compression) — mixture of gas and air compressed

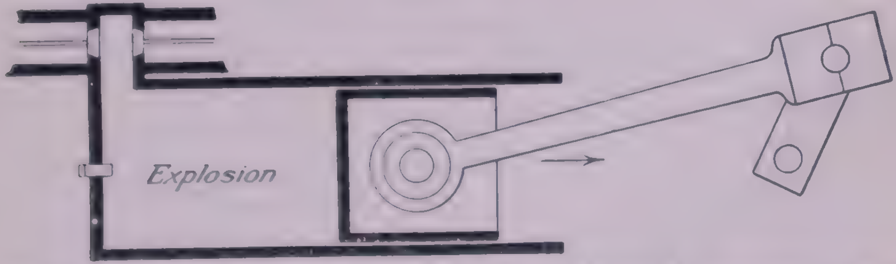

Fig. 97. — Third stroke (combustion) — mixture is exploded and expands, driving the piston forward

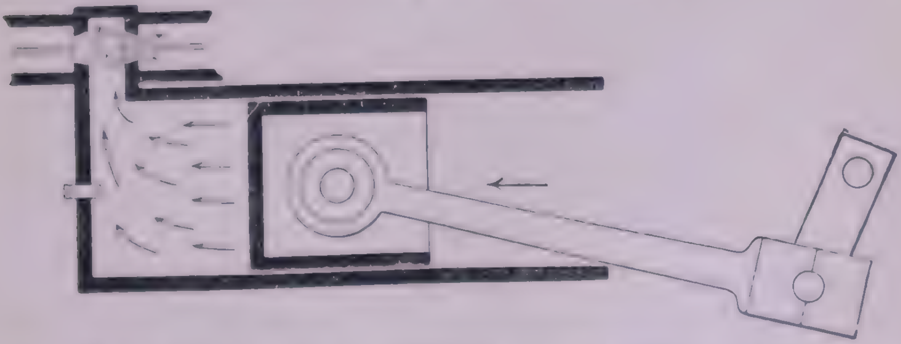

Fig. 98. — Fourth stroke (exhaustion) — the burned-out mixture of gas and air expelled from the cylinder

THE FOUR-CYCLE GAS ENGINE

sunlight. Likewise, if we trace back other forms of energy of which man makes use we shall find that they all come eventually to the sun as the original source. Can you trace back to the sun the energy of the gasoline engine and that of the electric motor?

Two kinds of energy are commonly distinguished — kinetic and potential. A body in motion, such as a flywheel, is said to possess kinetic energy. As an illustration of potential energy we may take the case of an old-fashioned clock run by weights. When the clock is wound up, the weights are lifted; then these weights by virtue of their position are able to do work and hence are said to possess potential energy. Another illustration is the spring of a watch, which on account of its strain has the power to do work in turning the wheels of the watch.

Scientists through a study of many forms of energy have come to an important conclusion known as the law of the conservation of energy. This law may be stated as follows: Energy can be neither made nor destroyed; in other words, the amount of energy in the universe remains unchanged. This law has an interesting bearing on the question as to whether it is possible to make a perpetual-motion machine. For many years people have been trying to invent such a machine; and occasionally one reads in the papers of some inventor who claims to have solved the problem. But the law just stated shows that a perpetual-motion machine is impossible, because when the claims of these inventors are carefully analyzed they really mean that more energy comes out of the machine than is put into it — a statement which is equivalent to saying that energy may be made out of nothing.

Carburetion system. Before the gasoline is allowed to enter the cylinder, it is vaporized and mixed with air, so that it will explode in the cylinder. The machinery which thus prepares the gasoline is called the carburetion system. The most common kind of carburetor is the spraying type. The gasoline is usually drawn through small openings by the suction of the piston on the jet or nozzle, forming a fine spray. At the same time, it is mixed with air in the proportion of about one part of gasoline vapor to fifteen parts of air by weight. The richness of the mixture can be changed to meet weather conditions. This mixture is led into the cylinder and put under pressure before it is exploded.

Feed systems. The various systems of feeding the gasoline from the gas tank to the carburetor are classified as gravity, pressure, and vacuum. In the gravity system, the tank is placed higher than the carburetor and the gasoline runs down of its own weight. In both the other systems, the tank is lower than the carburetor. In the pressure feed system, the gasoline is forced to the carburetor by applying a pressure in the gas tank. In the vacuum feed system, a vacuum is formed in a small auxiliary tank located just above the engine. This vacuum permits the atmospheric pressure to force gasoline through the pipe, just as water is forced up through a cistern pump. From the small tank the gasoline passes by its own weight down to the carburetor.

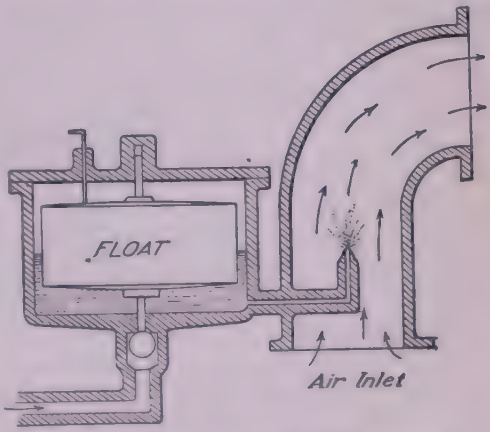

Fig. 99. — Elements of simple float-feed carburetor

Muffler. When the gases escape from the engine after the explosion, they make a very loud noise. In order to silence this, a muffler is used. This is cylindrical in shape and is made up of several compartments separated by partitions in which is a series of holes; the gases so pass through these holes that they finally leave the muffler with only a slight hissing noise.

The distance an engine will run on a gallon of gasoline varies with the make of the car, ranging from ten to twenty-five miles. It varies also with the same car according to season and the way the car is used.

Lubricating system. In order to lessen the wear from friction between the parts of the engine, they must be kept supplied with oil. Three principles are involved in the various methods of lubrication. (1) The oil is placed in the crank case and then *splashed* by the splasher spoons on the revolving crank shaft to the parts needing lubrication. (2) The oil may be pumped from the crank case to a point above the part needing lubrication and then allowed to flow down by gravity. (3) The oil may be pumped under pressure directly to the parts to be lubricated. The systems in use in various makes of cars employ one of these principles or some combination of them.

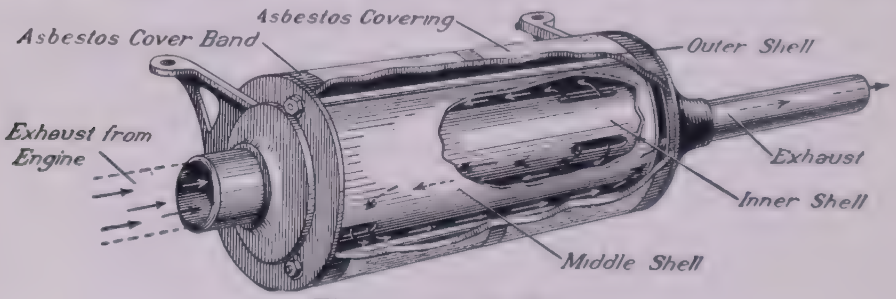

Fig. 100. — Muffler

Cooling the engine. The combustion of gases in the cylinder produces a large amount of heat, and the cylinder, if it were not cooled, would soon become heated to such a high temperature as to interfere seriously with the working of the engine. Therefore some device must be used to keep the cylinder from getting too hot. This purpose is accomplished by the use of either air or water. The air-cooled engines are constructed in such a way as to expose a large surface for cooling. In most cases a fan or some other device is used for forcing drafts of air against the cylinder.

The air system of cooling has the advantage of simplicity and is much easier to operate, especially in winter when there is danger that water will freeze. The air system of cooling is used extensively in localities such as Wyoming, where water is not plentiful and a water-cooled engine might be put out of operation if the water should be accidentally lost. A very large number of cars found in such localities use engines of the air-cooled type. On the whole, however, the water system is more satisfactory and is used by nearly all makes of cars.

In the water system of cooling, the cylinder is surrounded by a jacket kept filled with water. The circulation of this water is maintained in one of two ways — the natural system or the pump system. In the natural system, the water circulates as in the hot-water heating system (described on page 27), the hot water rising and the cold water flowing in to take its place. In the pump system, the water is forced around through the tubes by means of pumps operated automatically by connection with some revolving part of the engine. The water is cooled by passing through a radiator exposed to air and containing many tubes which give a large cooling surface. Fans help to draw the air through the radiator openings by means of suction. Motor-meters — special forms of thermometers — may be attached to the water inlet of the radiator in order to give warning when the engine becomes too hot. In winter alcohol is added to the water to prevent freezing.

DEMONSTRATION 39

Purpose. To show how the gas engine works.

Apparatus. Two large-mouthed bottles; pan; coffeepot; Bunsen burners; small gas engine or model of a gas engine; induction coil; cells.

Directions. 1. To show the need of a mixture of gases to cause an explosion: Fill an ordinary pan about a third full of water. Fill one large-mouthed bottle with water, and fill another half full. Invert them both in the pan of water. Connect a piece of rubber tubing with the gas jet. Put the other end of the tubing over the edge of the pan and under the mouths of the bottles. Then turn on the gas till the water is forced out of the bottles. Then turn off the gas. Take out the bottles and put a piece of cardboard over the mouth of each. Bring a lighted match to the mouth of each bottle after taking off the cover. What is the difference in the action of the two? What does this show? Partially fill the bottles again with water to see what proportion of air and gas gives the loudest explosion. If illuminating gas is not available, hydrogen gas may be generated by using zinc and hydrochloric acid as explained on page 73.

2. To show that this explosion has the power to do work: Near the bottom of the side of a coffeepot, cut a hole big enough to admit the end of a Bunsen burner. Halfway up on the side make a small hole. Turn on the gas and bring a lighted match near the small hole. Why does the cover fly back? Close the cover and see how many times it can be made to fly back. Turn off the gas and clean out the products of combustion from the pot. Then try the experiment again. What do the results show?

3. To show how the gas is ignited: Set up an induction coil and cells and show the formation of the spark.

4. Run a small gas engine with illuminating gas. Notice carefully how each part works. Or make a study of a model. Make a drawing and explain the uses of the various parts.

THE TRANSMISSION MECHANISM

Clutch. The clutch is a device by means of which the engine may be allowed to run alone without moving the wheels of the automobile. This device serves two purposes. When starting the car, it is necessary to allow the engine to attain sufficient speed before putting on the load; then, after the engine is once started, the clutch may be gradually thrown in and the car started. And again, when it is desired to stop for a very short time, the clutch may be thrown out and the engine need not be stopped; this use of the clutch saves stopping and then starting the engine again. Another purpose of the clutch is to permit a change of speed ratios, when starting the car and at other times, by shifting the gears. The clutch is first thrown out, the gears are shifted, and then the clutch is thrown in again. The most common kind of clutch is the friction type, in which the parts are held so closely in contact by springs that they rotate together. The tension of the springs is released by means of a foot pedal, thus allowing the parts to operate separately.

Gear box. The gear box is a mechanism by means of which the ratio between the speed of the engine and the driven speed of the car may be changed. This box contains different combinations of gears which are controlled by a lever. Most cars have three forward speeds: first, or low speed; second, or intermediate speed; and third, or high speed. In some large, heavy cars, such as buses, four forward speeds are provided. The lower speeds are used when starting the car and when traveling on hilly or muddy roads. The gears are said to be in *neutral* when the sliding gear is not in mesh with the gear that drives it. When the gears are in neutral, the engine may be allowed to run idle, as it runs when the clutch is thrown out. The reversing mechanism also, by means of which the car is driven backwards, is located in the gear box.

Power transmission. Power may be transmitted from the gear set to the wheels by means of sprockets and chains, or by means of a propeller shaft and suitable gears on the rear axle. The latter method is the one now commonly used. The chain drive was formerly used on commercial cars but is now being rapidly discontinued. The propeller shaft and gear drive has the advantage over the chain drive that it is enclosed and hence can easily be kept lubricated and free from dirt.

Differential. It is necessary that the rear wheels revolve at different speeds when the car turns a corner, while at the same time both are being driven by the engine. This is accomplished by means of the differential, which is a gear mechanism connecting the halves of the rear axle at the center. The gear works automatically according to the resistance of the road against the wheels.

THE ELECTRIC SYSTEM

Electricity plays an important part in the running of the automobile. It runs the motor that operates the starter; it furnishes the spark that ignites the gas; it furnishes the power for the lamps; it operates the electric horn; and some cars have automatic wind-shield wipers run by small motors.

Storage battery. The heart of the entire electric system is the storage battery. When the generator is making more electricity than is needed to run the car, it then charges the battery, and the chemical energy is later transformed into an electrical current. When the generator does not furnish enough electricity, then the battery supplies it. The word *storage* suggests its similarity to a reservoir of the waterworks of a city.

Construction. The automobile storage battery consists of three or more cells joined together and enclosed in a single battery box. Each cell consists of a hard rubber jar in which are placed two kinds of lead plates, the positive and the negative. These plates are insulated from each other by separators and are submerged in a solution of water and sulphuric acid, called the electrolyte, with a specific gravity of about 1.3 when the battery is fully charged. The term specific gravity is used to compare the weight of a substance with the weight of an equal volume of water. A specific gravity of 1.3 means that the weight of the liquid is 1.3 times that of an equal volume of water. The open spaces in the positive plates are filled with a chemical called lead peroxide, and those of the negative plate with spongy lead. Each cell has an opening in the center of the cover provided with a cap that can be unscrewed when one wishes to test the cell or to add distilled water to take the place of that which evaporates.

Operation. The battery stores chemical energy, not electricity; and when the battery is working, this chemical energy is changed to electric energy. During the process of discharging, a chemical change takes place by which the lead peroxide on the positive plates and the spongy lead on the negative plates are changed into lead sulphate. In this action sulphur is taken from the liquid, and hence the specific gravity is lowered. When the battery is charged by sending a current through it, the reverse of this action takes place. The lead sulphate on the positive plate is changed to lead peroxide, and that on the negative plate to spongy lead, while the sulphur goes back into the liquid, thus raising its specific gravity. Hence the specific gravity of a battery is an indication of the condition of the battery — a high specific gravity indicating a full charge, and a low gravity a low charge.

Care of battery. The battery should be examined about once a week in summer and once in two weeks during the winter. Enough distilled water should be added to cover the plates in order to replace that lost by evaporation. The charge of the battery is tested by a hydrometer syringe. A sample of liquid is drawn up into the tube. (This should be done before water is added.) Inside this tube is a bob or float weighted with small shot. This sinks in the liquid to a certain level, and on the stem of the float are figures showing the specific gravity. This float works on the principle that a floating body sinks in a liquid till it displaces its own weight of the liquid. Hence, the lighter the liquid the deeper the float will sink. Ordinarily the battery is kept charged by the generator or dynamo in the car. If this does not keep the battery sufficiently charged, the charging rate of the generator can be increased. If the battery becomes very low, it should be taken out and charged at a charging station, or with a home recharger. To prevent overcharging when the car is being run for long distances during the hours of daylight only, it may sometimes be wise to turn on the lights during the day.

DEMONSTRATION 40

Purpose. To show how to use a battery hydrometer syringe.

Apparatus. Battery hydrometer syringe; sulphuric acid; tumbler; measuring glass.

Directions. 1. Fill the tumbler a third full of water. Measure it. Draw some water into the tube of the syringe and note where the float stands.

2. Add measured quantities of sulphuric acid to the water and test with the syringe till the float reads "Half Charge." What percentage does the amount of acid added form of the amount of water used?

3. Continue to add measured quantities of acid to the solution and to test till the float reads "Full Charge." What percentage does the total amount of acid added now form of the amount of water used?

Starter and generator. In some cars the same machine that works the starter charges the battery. This machine is called a motor-generator. If electricity is supplied to it, it acts as a motor and works the starter. When the car is running, the motor-generator acts as a generator and charges the battery. In other cars there are two distinct machines — a motor acting as a starter, and a dynamo acting as a generator to charge the battery.

Ignition system. The purpose of the ignition system is to explode the gases in each cylinder at the proper time, in order that the piston may be forced down. The heat to ignite the gas is furnished by an electric spark. The source of electricity may be either dry cells, storage batteries, generators, or magnetos; or a combination may be used. The switch that regulates the time of explosion is controlled by means of a cam shaft driven by the engine and so set that the explosion occurs at the proper time. A part of the ignition system is an induction coil, which is a device that delivers a current of sufficient strength to cause a spark across the spark-plug points in the cylinder. The spark plug is composed of two points separated by a short distance, across which the current jumps, producing the spark that sets fire to the gases.

Lights. Three means of lighting automobiles have been used: kerosene, gas, and electricity. In the gas system, a tank containing acetylene gas under pressure is attached to the car. Electricity is now most commonly used. This has the advantages of cleanliness, reliability, and ease of operation, the lights being turned off and on by operating a switch.

Three types of electric lighting systems are in use: that using the dynamo; that using the storage battery; and that using both the dynamo and the storage battery. In the last system the current to the lamps is furnished by the battery, but the dynamo keeps the battery charged. This combination system is the one most commonly used.

Electric horn. Two types of electric horns are made — the vibrating type and the motor type. The first works on the principle of an electric bell, with the difference that the moving armature causes a vibration of a diaphragm instead of striking a bell. In the other type of horn a motor turns a steel-toothed wheel which operates against a steel button fastened to a metal diaphragm. The sound thus produced is magnified by means of the horn that encloses the diaphragm.

THE CONTROL APPARATUS

Relation to different systems. The dashboard with all the adjacent controls might well be called the nervous system of the car. The dashboard might be likened to the brain, and the connections between the dashboard and the various parts of the car might be likened to the nerves of the nervous system in man. The driver here is in control of the various parts of the car. Some of these controls, together with the systems of the cars with which they are connected, are shown in the table on page 278. Not every car has all these controls; this list represents a combination of what may be found in a number of cars.

SYSTEM WITH WHICH CONNECTED	CONTROL (SEE FIGURE 101)
Carburetion system	Throttle lever (to control amount of gasoline) Accelerator pedal (to control amount of gasoline) Choke (to regulate richness of mixture) Gasoline gauge (to show amount in tank)
Lubricating system	Oil gauge
Cooling system	Motometer
Transmission system	Clutch pedal Gear shift lever
Ignition system	Ignition switch Spark lever
Electric system	Starting pedal Lighting switch Horn button Ammeter
Braking system	Foot brake pedal Hand brake lever
Steering system	Steering wheel

Thus the driver is in close touch with the various systems of the car; and if he knows something about how the different systems work, even though only in an elementary way, he can control the car more intelligently and can take more pleasure in driving.

Starting the car. When the driver presses his foot on the starting button, the starter is set in motion. The supply of gasoline may be controlled by either the foot or the hand. At first the clutch is thrown out by means of the foot pedal, and then it is allowed to come back after the gear has been shifted. Through a change in the gear box the gear ratio is gradually shifted into high. The direction of the car is controlled by the steering wheel, which connects with the two front wheels. The rate of speed and the distance traveled are indicated by the speedometer. While learning to drive seems very complicated at first, after a while the motions become automatic just as in walking.

The average car has an engine of from twenty-five to fifty horsepower; on racing cars engines of very high horsepower are used. Speeds have been attained exceeding those of the locomotive. Special racing cars have traveled 120 miles in an hour and have gone a single mile in twenty-three seconds.

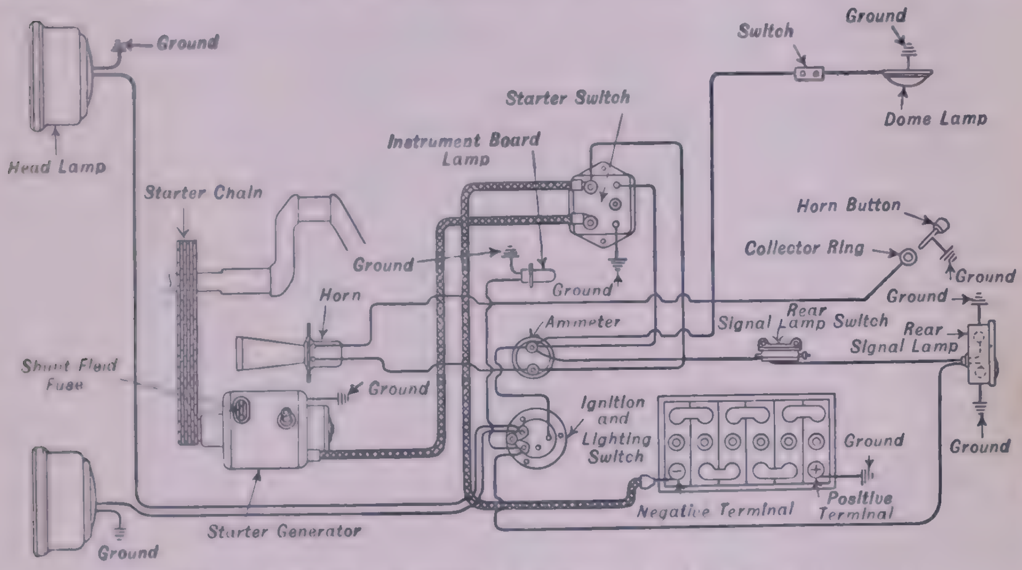

Fig. 101. — Wiring diagrams of starting and lighting systems

Stopping the car. Several means may be used to stop the car: shutting off the supply of gasoline, turning off the ignition, throwing out the clutch, and applying the brakes. The most common kind of brake is a band brake, which works on a brake drum attached to each rear wheel. The brake may also be attached to a drum on the driving shaft. Beside the ordinary foot brake, another brake is usually provided, known as the emergency brake, which is generally operated by hand. The four-wheel brake is a recent innovation that has been gaining in favor. When the car is going down a hill, a braking effect may be produced by shifting from high speed to intermediate or to low.

FIELD EXERCISE 5

Purpose. To study the parts of an automobile to see how it is run.

Directions. 1. Arrangements should be made with some mechanic in a garage to have the class visit the shop when an auto is being taken apart to be repaired. The uses of the various parts can be explained to the members of the class.

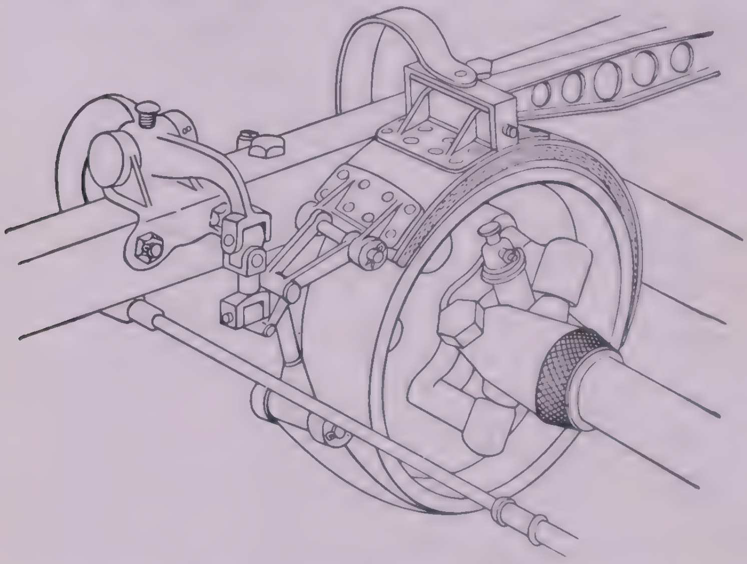

Fig. 102. — Shaft brake of band form

2. Arrangements may doubtless be made also with the parents of some members of the class to take small groups on an auto ride and explain the method of running a car.

WINTER CARE OF CAR

Radiator. In the cold climate of the northern states, winter driving is attended with difficulties that require special attention. In those cars provided with water-cooling systems; some antifreezing solution, such as alcohol, must be added to the water. As this evaporates rapidly, more must be added from time to time. No danger from freezing need be anticipated if this precaution is well attended to. Pure glycerine may be added to reduce the rate of evaporation.

The following table shows the temperatures at which the mixtures of denatured alcohol and water will freeze. By means of a hydrometer, similar to the one used in testing the battery but adapted to liquids lighter than water, the specific gravity of the liquid may be determined and, from this, the freezing point.

FREEZING POINTS OF DENATURED ALCOHOL MIXED WITH WATER

PER CENT OF ALCOHOL BY VOLUME	SPECIFIC GRAVITY OF SOLUTION	FREEZING POINT
30	.964	10 below zero
40	.954	20 " "
50	.933	32 " "
60	.913	45 " "

Battery. Special care should be used in testing the battery, because as the battery becomes discharged its freezing point becomes higher and there is increased danger of freezing. There is no danger that a fully charged battery will freeze. The following table shows the freezing points for different conditions of charge:

SPECIFIC GRAVITY	CONDITION OF BATTERY	FREEZING POINT
1.275 to 1.30	Fully charged	90 below zero
1.210	½ "	20 " "
1.160	¼ "	Zero
1.120 or below	Discharged	20 above zero

Lubrication. Considerable difficulty is experienced with the lubrication, since the oils used in summer stiffen at winter temperatures, and the water that collects in the oil freezes. Special light oils that freeze at much lower temperatures are used for winter driving.

Care in driving. On account of the snow and ice in the streets, unusual care should be used in winter driving. Skidding is one of the great dangers. In the first place, chains should be used very freely. The car should be driven more slowly and carefully than under ordinary conditions, to lessen the possibility of skidding.

Heating the car. Three methods have been used for heating cars: hot water, exhaust gas, and hot air. In the hot-water method, pipes are laid in a heater box in the floor of the car, and these are connected with the water used in the cooling system. Thus a circulation of hot water is maintained through the heating pipes. In the exhaust method, the heating pipes are connected with the exhaust pipe, and the hot gases pass through the heating pipes on the way to their escape. The hot-air method is very similar in principle to the hot-air system used to heat houses. A metal jacket is fastened over the exhaust pipe. Air is led from the fan through this chamber, where it is heated; and it is then forced through a pipe opening in the floor of the car. Thus a continuous stream of fresh heated air is brought into the car.

OUTLINE SUMMARY

The Automobile

- I. Uses of automobiles
- II. History of the automobile
- III. Automobile accidents
  - 1. Their extent
    - *a.* Property loss
  - 2. The causes
  - 3. The remedies
    - *a.* Precautions for drivers
      - (1) Rules for driving
    - *b.* Precautions for pedestrians
    - *c.* Control by law
- IV. The body
- V. The running gear
  - 1. Axle and wheels
    - *a.* Tires
  - 2. Frame and springs

VI. The power plant
  1. Internal combustion engine
    a. How it works
    b. Starting
    c. Comparison with steam engine
    d. Energy
  2. Carburetion system
    a. Feed systems
    b. Muffler
  3. Lubricating system
  4. Cooling the engine

VII. The transmission mechanism
  1. Clutch
  2. Gear box
  3. Power transmission
  4. Differential

VIII. The electric system
  1. Storage battery
    a. Construction
    b. Operation
    c. Care
  2. Starter and generator
  3. Ignition system
  4. Lights
  5. Electric horn

IX. The control apparatus
  1. Relation to different systems
  2. Starting the car
  3. Stopping the car

X. Winter care of car
  1. Radiator
  2. Battery
  3. Lubrication
  4. Care in driving
  5. Heating the car

QUESTIONS FOR CLASS DISCUSSION

1. Name all the uses that you have seen made of automobiles.
2. Which is more useful, the auto or the electric trolley car?
3. Which has more advantages, the electric auto or the gasoline auto?
4. How does the gasoline engine differ from the steam engine?
5. What purpose does each of the following systems serve in the auto: the carburetion system, the ignition system, and the cooling system?
6. Explain how the engine works.
7. What is the best method of lighting the auto?
8. How does the chauffeur control the car?
9. What are the best ways to prevent accidents?

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CHAPTER XVIII

THE STEAMBOAT

1. In what ways are the means of travel on water now in use better than were those in use when Columbus discovered this continent?

2. How is the submarine made so that it is able to travel under water?

EARLY TYPES OF BOATS

Probably the first boat used by primitive man was a log, which may have been kept in motion by using a branch for an oar. From this beginning, two types of boats developed. One type was made by digging away the center of a log; improving on this type, men later constructed canoes made of bark or other light material. The other early form was the raft, made by fastening several logs together. At first the rafts were driven by hand; later, sails were attached to them.

Fig. 103. — The first boat

Eventually the raft developed into a large boat, made by fastening planks and logs together to give it a spoon shape. These early boats were propelled by both oars and sails. About 1100 B.C. the first rudder appeared in the form of an oar projecting from the stern of the boat. This type of rudder was used for many hundreds of years.

The best type of boat of ancient times was made by the Romans, whose boats or galleys were in some instances four hundred feet long. Oars were depended on chiefly for propelling the boat, several hundred rowers sometimes being employed in a large boat. Sometimes there were three rows of oars, one above another.

During the next few centuries little progress was made in boat building. Gradually less reliance was placed on oars and more on sails, until the sails replaced the oars entirely; the boats of this time, then, might be called sailing ships. The rudder was fastened to the boat and worked by means of a device called a tiller.

About the middle of the thirteenth century the compass was first used as a guide for steering the boat. Before this time sailors had steered at night by the North Star. In cloudy weather they were easily lost. The use of the compass enabled the sailors to undertake much longer journeys than they had ever dared to try before. Without the aid of the compass probably the New World would not have been discovered when it was by the people of Europe.

THE FIRST STEAMBOATS

The next great development was the use of steam power in propelling boats. The first boat to be driven by steam was made by an American named James Rumsey. In 1786 this boat was driven at the rate of five miles an hour. This was propelled by means of a piston working in a cylinder. When the piston was raised, the cylinder was filled with water; and when the piston was pushed down, the water was forced out; and the reaction of this against the water in the river caused the boat to move ahead.

In 1787 another American, named John Fitch, made a boat in which the oars were worked by a steam engine. A speed of three or four miles an hour was attained. While both of these were interesting experiments, neither was a success commercially.

Robert Fulton's *Clermont.* The first really successful steamboat was built by Robert Fulton. In 1807 his steamboat, the *Clermont*, made a trip on the Hudson River from New York to Albany — a distance of 150 miles — in thirty-two hours. This trip had been regularly made by sailboats in about four days. The *Clermont*, which was 130 feet long, was propelled by means of paddle wheels fifteen feet in diameter, one on each side of the boat, turned by a steam engine. The *Clermont* continued to make regular trips carrying passengers between these cities.

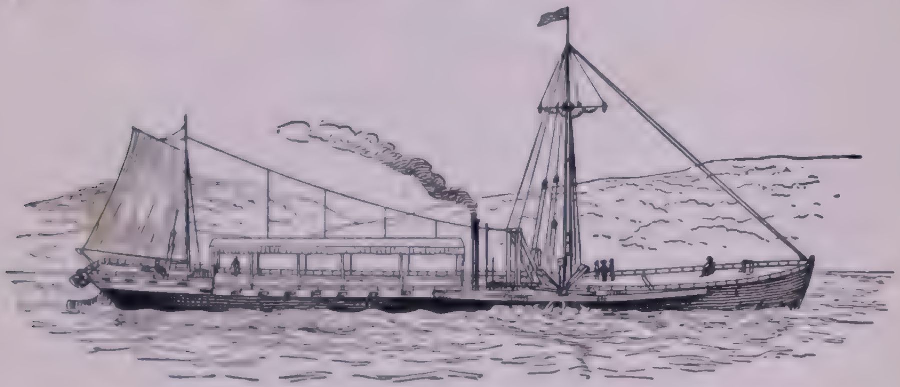


Fig. 104. — Fulton's *Clermont*, the first steamboat

THE TRANSATLANTIC STEAMBOATS

Other steamboats were soon built, and twelve years later the steamship *Savannah*, using both steam and sails, crossed the Atlantic Ocean in twenty-six days. The first steamboat to cross the Atlantic using steam all the way was the *Royal William*, which crossed from Nova Scotia to the Isle of Wight in seventeen days.

The next great improvement in the steamboat was the invention by John Ericsson of the screw propeller. This is a wheel without a rim, entirely immersed in water, and fastened at the stern of the boat. Its spokes, in the form of blades, are placed in such a way that as they rotate and push against the water they force the boat ahead. The first steamboat using a screw propeller crossed the Atlantic in 1839. Since that time there have been many improvements in the ocean steamship.

The first ocean steamers were made of wood; later, iron was used. The first iron steamboat crossed the Atlantic in 1850. About twenty-five years later, steel took the place of iron; and today our great Atlantic steamships are made entirely of steel.

The *Leviathan*. Such improvements have been made in the modern transatlantic steamships that they are floating hotels with the comforts and conveniences that are obtainable on land. Some have such conveniences as drawing rooms, smoking rooms, reading and writing rooms, porches, cafés, and even gymnasiums and swimming pools. One of the largest of these ships, the *Leviathan*, is 907 feet long and 100 feet wide. It uses turbine engines with a maximum horsepower of 100,000.

Some idea of the preparation necessary for a trip across the ocean may be gained from the following table showing the amounts of certain kinds of food consumed in one round trip:

FOODS	POUNDS	FOODS	POUNDS	FOODS	QUANTITIES
Meat	186,000	Cabbage	20,000	Apples	600 boxes
Flour	70,000	Sugar	15,000	Oranges	400 boxes
Potatoes	60,000	Butter	15,000	Eggs	80,000
Fish	56,000			Milk	2,000 quarts

Altogether, 500,000 pounds of food are eaten in one voyage.

The speed attained by these ships is shown by the following figures: The *Mauretania* crossed the Atlantic Ocean in four days and ten hours at the rate of thirty miles an hour. (Compare this with the record of twenty-six days made about a hundred years before by the first steamboat to cross the Atlantic.) On one occasion the *Leviathan* traveled at the rate of thirty-two miles an hour for a distance of seventy-five miles.

The greatest speed has been attained by small motor boats used largely as pleasure boats, which have reached a speed almost comparable with that attained by the automobile. The motor boat *Miss America* in the year 1920 traveled at the rate of seventy-seven miles an hour in a race on Lake George, New York. More recently motor boats are reported in the newspapers to have reached a speed of ninety miles an hour.

Fig. 105. — A modern steamship

THE STEAM TURBINE

In recent years there has been developed a new type of steam power unit called the turbine, which is being much used on steamships. It is something like a water wheel, which is turned by the force of the water striking against its paddles. In the steam turbine the steam is led through small nozzles and caused to strike against many blades on a revolving drum. The steam is traveling at a very great velocity, and as it strikes against these blades it causes the drum to revolve at a tremendous speed. (See figure 106.) There are several series of these blades and nozzles, so arranged that the steam is guided from one set to the next, and thus the steam is used repeatedly.

These turbines are now used on such large steamships as the

Mauretania, as it is found that they have the following advantages over the ordinary steam engine: (1) There is no vibration, and so the boat may travel smoothly without unpleasant jarring. (2) They occupy less space. (3) They are more economical at high speeds. (4) They are more easily tended and require fewer repairs.

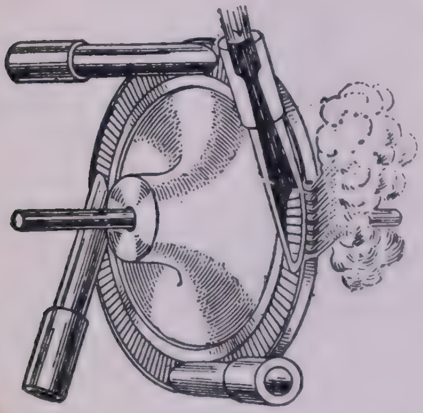


Fig. 106. — Steam turbine with one set of nozzles

The steam turbine is used not only in ships but also in power plants on land. The growth of the turbine in recent years is shown by the following figures: In the year 1917 in central station equipments 79 per cent of the power generated was credited to steam turbines, and 21 per cent to steam engines. In 1920 the proportion of steam turbines had increased to 84.5 per cent. At the present time one company alone is constructing fifty-eight of these turbines, ranging in horsepower from thirty thousand to seventy thousand each.

DEMONSTRATION 41

Purpose. To make a simple steam turbine.

Apparatus. Flask; rubber stopper with one hole; glass tubing; toy windmill.

Directions. 1. To make a toy windmill: Take a piece of paper about six inches square and cut from each corner inward nearly to the center. Fold over every other point. Pass a pin through these four points, through the center of the paper, and then into a wooden handle.

2. Heat a piece of glass tubing and draw it out nearly to a point. Break it off, leaving a very small hole. Put this tube in the hole of the rubber stopper, and then insert the stopper in a flask so that the small point is uppermost. Fill the flask a third full of water. Heat the flask till the water boils vigorously. Then hold the windmill over the glass tube in such a way that the escaping steam strikes against the paper.

THE DIESEL ENGINE

During the last fifteen years another type of engine for driving ships — known as the Diesel Engine — has been making its way, and in recent years its use has been rapidly increasing. This is an internal combustion engine which burns heavy oil as a fuel. It is similar in principle to the engine used in the automobile, with the difference, however, that no electric spark is required to ignite the fuel. On the downward stroke the engine draws air into the cylinder; and on the upstroke it compresses this to the enormous pressure of about five hundred pounds to the square inch, which is about five times the pressure in an automobile engine. This pressure raises the temperature of the air to such a high point that when, at the top of the stroke, oil spray is forced into the cylinder through a valve, the heated air ignites the fuel; the resulting explosion drives the piston down.

The chief advantages of this engine as compared with the steam engines are the following: The cost of fuel is much less; there is more space available for cargo, since the ship carries less fuel; and there are no boilers or stokers. The chief disadvantage is that the first cost is greater.

The vessels propelled by this engine are often called motor ships. The first ship of this type was launched about 1909. In the ten years from 1914 to 1924 the amount of tonnage of the ships propelled by this engine had increased ninefold. At the present time some ships now in use are replacing their steam engines with Diesel engines; and many of the ships now in the process of construction are to be driven by Diesel engines.

HOW VESSELS ARE GUIDED

Compass. In the earliest times men did not dare to venture far from land; they steered by landmarks, by the sun, and perhaps by the flight of birds, and on clear nights by the stars. The compass was first used as a guide in steering ships between 1100 and 1200 A.D. In its first form it was a needle in a straw floating on water. About 1360 the needle was mounted on a pivot and inclosed in a box, as it is now used. A compass is a magnet mounted so that it can turn easily, and it always takes a north-and-south position. The power of a magnet to take this position was not known till the end of the eleventh century, and was then known to only a few learned men. They thought it unsafe to tell about the use of the compass in steering ships, for fear they would be considered magicians; therefore it was a long time afterward, probably over a hundred years, before the compass was in common use.

The tendency of the compass to point north and south is explained by saying that the whole earth acts like a huge magnet with its two magnetic poles near the geographic poles. Since the compass points to the magnetic north pole and not to the geographic north, for most sections of the earth a certain number of degrees must be added to or subtracted from the reading of the compass to get the true north. As one passes east or west, these corrections vary. In recent years much steel has been used in the construction of steamships, and it is found that the compass is influenced by this mass of iron near it. For these two reasons, therefore, some substitute for the compass in guiding ships has been sought.

LABORATORY EXERCISE 11

Purpose. To study the action of the compass.

Apparatus. Compass; two darning needles; knitting needle; cork; magnet.

Directions. 1. Magnetize a knitting needle by rubbing an end of the needle on one end of the magnet, and the other end of the needle on the other end of the magnet. Fold diagonally a piece of paper about one inch square. Place the needle at its middle in the crease of paper and suspend the paper by means of a fine thread. In what position does the needle come to rest? Compare with the compass. Move the needle and try several times. Does it always come to rest in the same position?

2. Magnetize a large darning needle by rubbing the point on the north pole of a magnet and the eye end on the south pole. Magnetize another needle by rubbing the point on the south pole and the eye end on the north pole of the magnet. Cut two thin pieces of cork from a stopper. Float the corks in a pan of water. Put a needle on each cork. In what position do the needles come to rest? Do the points of both needles point in the same direction? Can you explain?

3. Set the compass on a level table and notice the direction in which the needle points. Place pieces of iron and steel near it on the table and see if the needle is affected. Try a magnet.

Gyrocompass. Recently there has been invented a new type of compass called the gyrocompass, which is being used commonly, especially on battleships. The gyroscope is a wheel mounted on an axle inside of a frame. It tends to keep rotating in the plane in which it started. If the wheel is a large one, the strength of a man is not enough to change its plane of rotation.

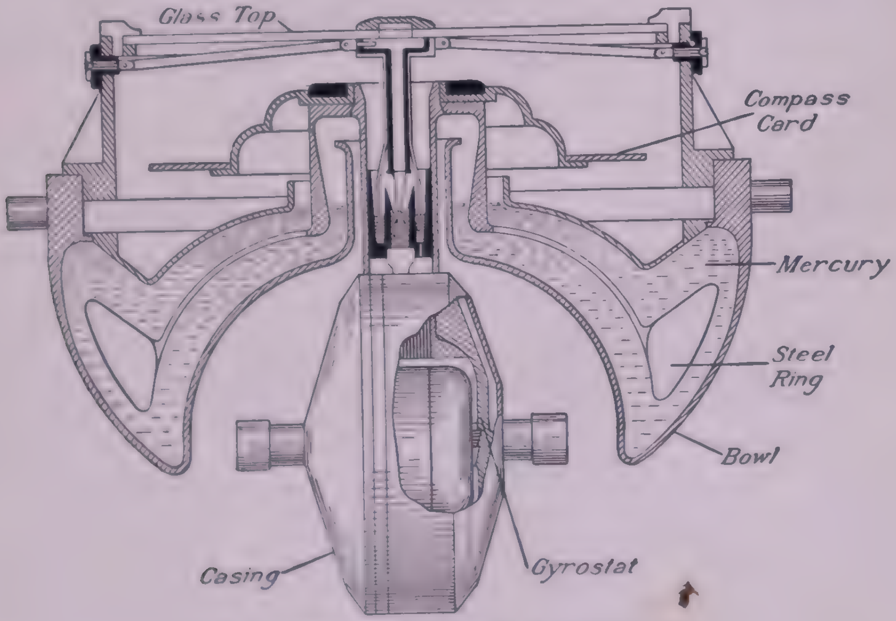


Fig. 107. — Section of gyrocompass

In the gyrocompass the wheel is set to rotating in a north-and-south plane and is kept in rotation at a high rate of speed by means of a motor. The gyroscope floats in a bowl containing mercury, so that the wheel keeps rotating in a north-and-south plane regardless of any motion of the ship. The top is covered with glass, and on this is a dial showing the points of the compass. Other dials may be placed in any part of the ship, and by means of electrical connections with the gyroscope the true readings are indicated on these dials.

DEMONSTRATION 42

Purpose. To see how a gyroscope works.

Apparatus. Toy gyroscope.

Directions. Set the gyroscope spinning by means of a string. With the axis of the gyroscope kept horizontal, try placing the instrument in a great many positions, as on the edge of a tumbler, on a string, on the tip of a pencil, on the end of the finger. How could this gyroscope be used to guide vessels?

PROVISIONS FOR SAFETY

Protection from accidents. In order to assure the safety of the large ocean ships, they are provided with a number of separate water-tight compartments, called bulkheads, so that if by accident water should enter one, it cannot flood the others. As a protection against icebergs an instrument is used which consists of a special thermometer placed near the forward end of the ship in a vessel through which sea water passes. The lowering of the temperature may indicate the presence of icebergs. This thermometer is connected with an indicator on the bridge. This can be so set that when a certain temperature is registered by the thermometer an electric gong rings and a red light shows as a warning to the one on watch. Protection from fire is assured by the use of steel instead of wood in the construction of the ship and by fire-detecting systems connected with the navigating quarters.

Protection from rocks. Protection from dangerous rocks and coasts is assured by signals conveyed under water. A bell is placed under water over the dangerous rocks, and the strokes are controlled from a shore station or a lightship by means of electricity or compressed air. The different bells can be distinguished by the varying number of strokes and the intervals between. The receiving apparatus consists of water tanks about two feet square fastened to the ship below the water line. Each tank contains an instrument which is connected by wires with a telephone in the pilot house. By this means the pilot can hear the strokes of the bell and can tell from their number and intervals the exact locality. These signals operate up to fifteen or twenty miles, regardless of fog or any other conditions of weather. They have already been the means of saving thousands of dollars' worth of property and many lives.

WHY A BOAT FLOATS

When a boat is made of wood, it is not difficult to understand why it floats; but when boats are made of a heavy substance such as steel, it is not so easy to understand. Whether a body will float or sink depends on its specific gravity. A body that has a specific gravity of less than 1 floats; a body that has a specific gravity of more than 1 sinks when placed in water. Since a piece of steel is so much heavier than water, how is it possible for a boat made of steel to float? The explanation is found in the fact that a large amount of air is inclosed within the steel sides of the boat, and the specific gravity of the steel and air combined is less than 1; that is to say, the whole volume is lighter than an equal volume of water.

DEMONSTRATION 43

Purpose. To learn why a boat floats.

Apparatus. Spring balance; stone; overflow can: catch bucket; wooden cylinder to fit overflow can; egg; salt; shot; test tube.

Directions. 1. To show the lifting force of water on a sinking body: Tie a string to a stone and weigh it in air by means of a spring balance. Submerge the stone in water and weigh it. How much has it lost? To what is this loss due?

2. To show the lifting effect of water on a floating body: Fill the overflow can as full of water as possible. Weigh the catch bucket. Weigh the wooden cylinder. Place it on the surface of the water in the overflow can and catch the overflow in the catch bucket. Find the weight of the water in the catch bucket. How does this compare with the weight of the block of wood?

3. Put some shot in a test tube and float the tube in a dish of water. Glass and shot are both heavier than water. Why then does the tube float? Why do steel ships float? Catch the overflow as in the previous experiment and compare with the weight of the tube and shot. Add more shot. What happens to the tube? Remove some shot. What happens? What fact does this illustrate about the loading and unloading of a boat?

4. To show the difference in the lifting force of fresh and salt water: Put an egg in a dish of fresh water. What happens? Put the egg in a strong solution of salt and water. What happens? What causes the difference? In which body of water would a boat sink deeper, Lake Superior or the Atlantic Ocean? Why?

THE ROTOR SHIP

The most recent development in ships is the rotor ship, which employs a principle not before applied in vessels. The force employed to move the boat is wind, but in place of sails rotating steel cylinders are used. In the first vessel on which the experiment was made, two hollow steel towers, each sixty-five feet high and ten feet in diameter, were erected. These towers are made to turn by means of a motor. The principle used is the one commonly employed in curving a baseball, known as the "Magnus effect." It may be stated briefly as follows: When a current of wind strikes a rotating cylinder, it exerts a force approximately at right angles to the direction of the wind.

In the trial trips made with a ship equipped with these towers the results compared favorably with those obtained with sailing ships. While the speed attained was slow, it is claimed that rotor ships are more economical both in operation and in cargo space.

SUBMARINES

During the recent European war our attention was especially called to submarines on account of the destructive uses to which they were put. The uses of submarines have been confined chiefly to warfare; so far little use for them in commercial life has been found.

History of submarines. During the Revolutionary War, David Bushnell made an attempt with a submarine to blow up a British ship in New York harbor. He actually succeeded in getting under one of the warships with a magazine of powder but was not able to fasten this to the vessel.

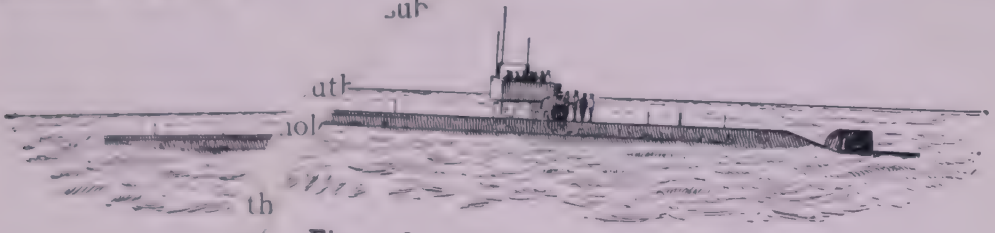


Fig. 108. — A modern submarine

Robert Fulton directed his attention to submarines about the year 1800. His experiments were partially successful, for he constructed a submarine which descended to a depth of twenty-five feet and remained three hours. He also showed how it was possible to use a submarine to blow up other boats in time of war.

We hear again of submarines during the Civil War, when the Confederates constructed submarine boats called "Davids." One of these was successful in sinking one of the United States warships, the *Housatonic*, by means of a torpedo. The submarine itself, however, was damaged by the explosion and sank to the bottom with its crew.

The first really successful submarines were built by Mr. Holland during the nineties. In 1892 the United States government made an appropriation to be used for the construction of submarines for the navy, and decided to adopt the Holland type. The first Holland was completed as a torpedo boat in 1900. These submarines have been greatly improved and have

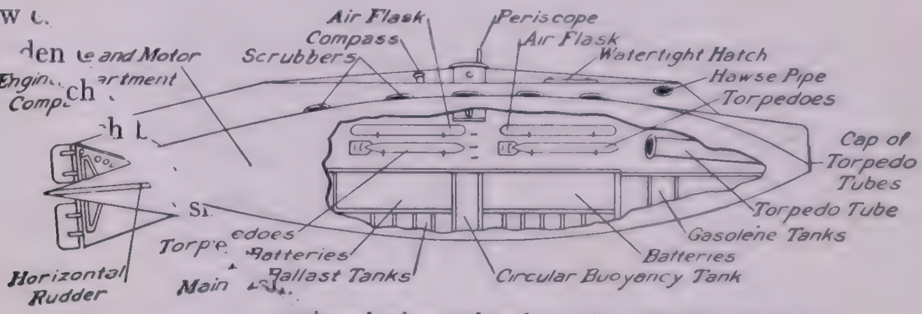


Fig. 109. — Sectional view of submarine (Holland type)

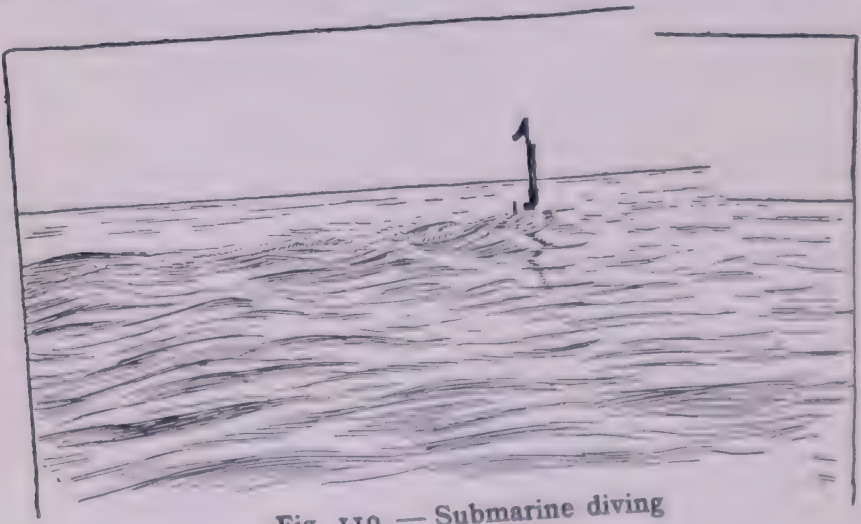


Fig. 110. — Submarine diving

been adopted by the more important navies of the wo One of recent make in the United States navy is 341 feet and 27 feet wide. It has a surface speed of twenty-four per hour. It carries seven officers and eighty men in the crew. It can cross the Atlantic and return without taking in fuel.

How they rise and sink. Submarines are made so that they can run either on the surface or submerged. They are made to sink by admitting water to tanks, and can be made to dive by the action of the propeller and a horizontal rudder. They are made to rise again by pumping out the water. The depth to which they sink is indicated by means of gauges. The shell of the boat is made of strong steel so as to withstand the tremendous pressure of the water far below the surface.

DEMONSTRATION 44

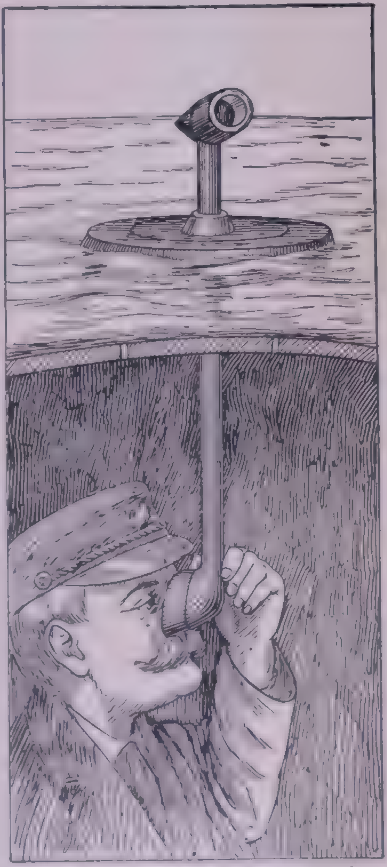
Purpose. To see how the submarine is made to rise and sink.

Apparatus. Large-mouthed bottle; rubber stopper with two holes; glass tubing; rubber tube.

Directions. Fill the bottle with water. Push a piece of glass tubing through one of the holes in the rubber stopper. Push one end of the rubber tubing over the glass tube. Put the stopper in the bottle and put the bottle in a dish of water.

2. Blow through the rubber tubing till the water is forced out of the bottle. What happens to the bottle? Why?

3. Fill the bottle again with water and put it in the dish. What happens? Why?



Courtesy of Harper and Brothers

Fig. 111. — Periscope of submarine

How the submarine is propelled. Two sources of power are used for propelling the boat. When the boat is on the surface, a gasoline or oil engine is used to run the boat, and this also runs a dynamo which charges a storage battery. When the boat is under water, the gasoline engine is shut off and the propeller is turned by a motor run by electricity from the storage battery. This also furnishes electricity for lighting the boat and for cooking.

In order to supply air for the passengers, tanks of compressed air are carried. In submarines used for war purposes, compressed air is used also to work machines to discharge torpedoes. These are so arranged that they can be discharged at an enemy's ship a long distance away.

Periscope. To enable the men in a submarine to see the surroundings on the surface of the water, a periscope is used. This consists of a long tube reaching to the surface of the water and containing reflecting prisms or mirrors so arranged that one looking through an eyepiece in the boat is able to see what is in front of the periscope. It can be turned so as to face any part of the horizon.

OUTLINE SUMMARY

THE STEAMBOAT

I. Early types of boats

II. The first steamboats
   1. Robert Fulton's *Clermont*

III. Transatlantic steamboats
   1. The *Leviathan*

IV. The steam turbine

V. The Diesel engine

VI. How vessels are guided
   1. Compass
   2. Gyrocompass

VII. Provisions for safety
   1. Protection from accidents
   2. Protection from rocks

VIII. Why a boat floats

IX. The rotor ship

X. Submarines
  1. History of submarines
  2. How they rise and sink
  3. How the submarine is propelled
  4. Periscope

QUESTIONS FOR CLASS DISCUSSION

1. Summarize briefly the changes that have taken place in the steamboat during the last hundred years.

2. What conveniences are found on a modern transatlantic steamship?

3. How does the steam turbine differ from the ordinary steam engine used on the locomotive?

4. Why is the gyrocompass taking the place of the ordinary compass as a means of guiding ships?

5. What provisions have steamships as a protection against accidents?

6. What uses can be made of the submarine in times of peace?

7. What features are found on the submarine that are not found on the ordinary boat?

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CHAPTER XIX

AIRPLANES AND AIRSHIPS

1. What progress has been made in the last twenty-five years in the development of air navigation?

2. How do the airship and the airplane differ in their construction and in the methods by which they are kept in the air?

AIRPLANES

For hundreds of years men have tried to devise means of flying. These efforts have been directed along two distinct lines involving two different principles. In one direction men have tried to devise some apparatus, such as balloons filled with gases, that would rise because they were lighter than air. In a very different direction other men have attempted to fly by using machines heavier than air, which are kept up in the air through their motion and the resistance of the air.

Early history of airplanes. Let us go back a few years and learn what was done in the early stages of flying and who some of the experimenters were. Birds fly by two methods: by flapping the wings and by soaring. The first crude flying machines imitated the shape and motion of a bird's wing while flapping. No success was attained in this direction, and later efforts were made on the principle of the soaring bird.

At the beginning of this century several men were carrying on experiments in flying. Otto Lilienthal, in Berlin, carried on experiments in gliding or soaring. He used large wings and, starting from a height of fifty feet or less, he would glide with the wind. He was killed in one of these flights.

Langley's experiments. Professor Langley, of Washington, D. C., carried on some successful experiments which contributed much to the progress of flying machines. He built small models which flew in still air.

Wright brothers. During 1900 and the years following, the Wright brothers, Orville and Wilbur, of Ohio, carried on successful experiments in gliding. They found that a vertical rudder in the rear was the best method of steering to the left and right, and that a horizontal rudder in the front was the best means of guiding the machine up and down. In 1902 they accomplished a glide of three hundred yards. In 1903 they attached an engine to one of their machines and made their first successful flight. Two years later they made a flight of twenty-four miles and landed in safety. These were the first true flights in heavier-than-air machines.

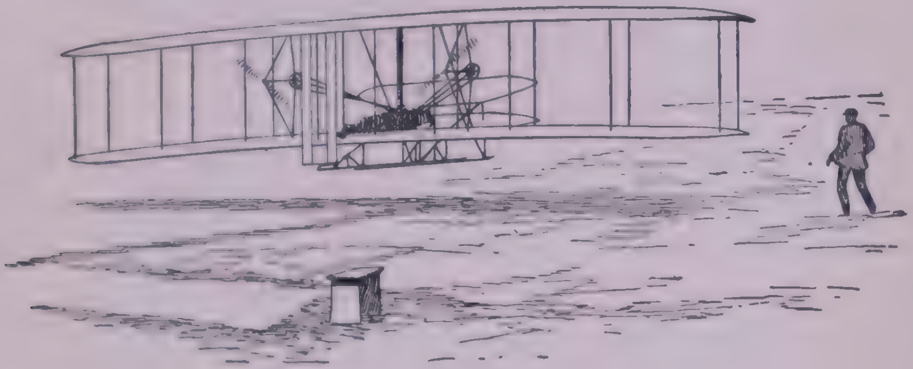

Fig. 112. — First Wright plane

In 1908 Wilbur Wright took his machine to France and demonstrated the practical value of the airplane. He remained in the air more than two hours and carried passengers at a height of four hundred feet.

Recent progress. From that time to the present, remarkably rapid progress has been made along the following lines: distances flown in non-stop flights, speed, height, time remaining in air, weight carried, and provisions making for greater safety.

Distance. The progress made in non-stop flights is shown in the following table:

DATE	DISTANCE	BY WHOM	WHERE
1905 . .	24 miles	Wright Bros.	America
1909 . .	English Channel	Louis Bleriot	France to England
1916 . .	812 miles	Lieut. Marchal	France to Poland
1919 . .	1,960 miles	Alcock and Brown	Across Atlantic
1923 . .	2,600 miles	Lieuts. Macready and Kelly	From Atlantic to Pacific Coast

This last flight — from Long Island to San Diego, California — was a milestone in the progress of aviation. This distance was covered in twenty-six hours and fifty minutes, at an average speed of 93½ miles an hour. The coffee in a thermos bottle which had been filled on the previous afternoon in New York was still hot on arriving at San Diego.

In 1924 Lieutenant Maughan made a dawn-to-dusk flight, with several stops, from New York to San Francisco in a flying time of seventeen hours and fifty-two minutes, and with a total time of twenty-one hours and forty-four minutes.

On one occasion two officers in the army air service ate breakfast in Canada and flew to Mexico in time for dinner the evening of the same day.

One of the most remarkable achievements in flying was the flight around the world successfully accomplished by a group of American army aviators. In the spring of 1925 these aviators started westward from Seattle, Washington. In 175 days they returned to the same city after traveling 26,100 miles. Their actual flying time was 365 hours. This flight was remarkable because the men were flying over unknown lands and encountered all sorts of unfavorable conditions of weather, such as dense fog, strong winds, and severe storms.

Speed. The progress in speed is shown in the following table:

DATE	RATE PER HOUR	BY WHOM	PLACE
1909	47 miles	Glenn H. Curtiss	Rheims
1912	72 miles		America
1916	137 miles	Carlstrom	America
1922	222 miles	Mitchell	America
1924	278.4 miles	Bonnett	France

This last record means that the man was traveling at the rate of 4½ miles a minute, or one mile in thirteen seconds. If this rate were maintained, a man could fly from New York to Chicago in less than four hours, or from New York to San Francisco in about ten hours. It was reported in the newspapers in 1925 that an American had flown at the rate of 303 miles per hour, or more than five miles per minute.

Length of time in air. Progress has been made also in the length of time an airplane can stay in the air, as shown by the following table:

DATE	TIME IN AIR	BY WHOM	PLACE
1908	2 hours	W. Wright	France
1916	6 hours	Ruth Law	America
1921	26 hours 19 min.	Stinson and Bertaud	America
1924	37 hours 59 min.	Coupet and Drouhin	France

One recent accomplishment that will increase greatly the length of time that an airplane can stay in the air is the ability to take gasoline from one plane to another while flying. This transfer of gasoline has been accomplished while the planes were traveling at the rate of a hundred miles an hour.

Height. The next table shows the progress made in the height to which airplanes have flown.

DATE	HEIGHT
1908	400 feet
1919	28,900 "
1923	36,555 "

made with a slightly curved surface, as it is found that these have greater lifting power than planes with flat surfaces. Wood has commonly been used in the construction of the planes and propellers, but now all-metal planes are being constructed out of aluminum and its alloys, even the propeller being made of metal.

Operation of airplane. *How the airplane remains in the air.* Having traced the development of the airplane from its crude beginnings to its present state, we may next inquire on what principle it works. The balloon is kept aloft because the gas which it contains is lighter than air; but the airplane is heavier than air and is kept aloft by another method. The principle is very much like that illustrated in the flying of a kite. If a person holding the string of a flying kite runs against the wind, the kite rises. There are three forces acting on the surface of the kite: the wind, the string, and the weight of the kite. In the airplane, the pull of the string is replaced by the motion of the propellers, which urge the airplane onward until a sufficient wind is generated to lift the airplane.

Stability. While flying, the planes encounter many cross-currents of air, which tend to make the airplanes unstable. In order to give the airplane more stability in a longitudinal direction — the direction in which the airplane is traveling — one or two horizontal planes are attached to the rear. To give stability in a lateral direction, several devices are used. In most biplanes, flaps (small wing sections) are hinged on the trailing edge of the main planes and can be raised or lowered. Another method often used on monoplanes is the warping of the tips of the planes.

Power. Gasoline engines are used to furnish the power to propel airplanes, because they are light and powerful. Engines of great horsepower are being used. The propellers are commonly two-bladed and from five to ten feet in diameter. They may be single or double and are generally placed in front; hence,

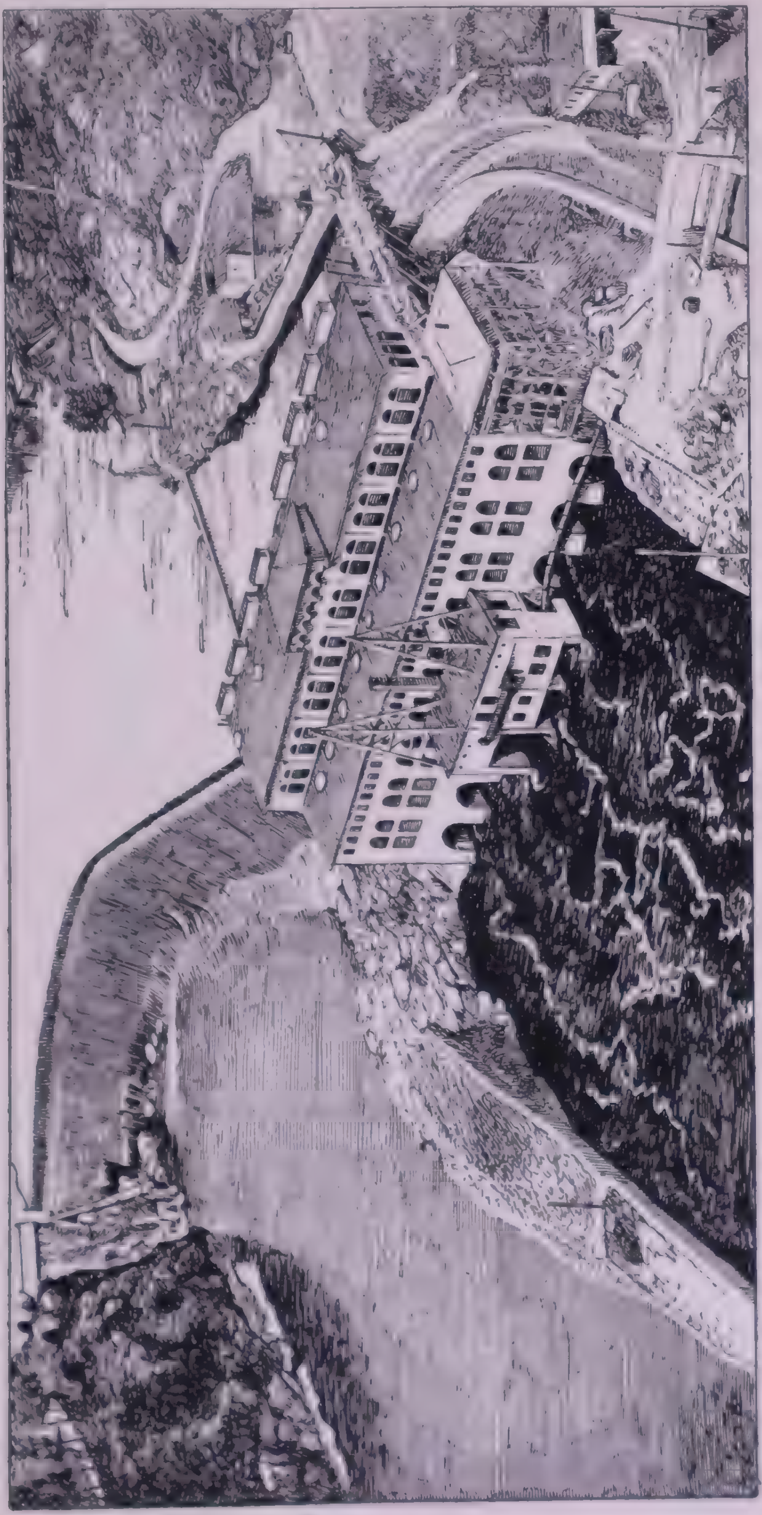

Fig. 116. — View from an airplane

correctly speaking, they are "tractor screws" (pulling members), rather than propellers (pushing members).

Starting the airplane. In order that an airplane shall glide through the air, it must have an initial motion given it before it is launched. The Wright brothers in their first experiments started their machine by means of a heavy falling weight which, by means of a cable attachment, drew the machine along a track and catapulted it into the air. Modern machines are mounted on wheels, and the motion is started by the propellers, which force the machine over the ground; this method of starting is known as "taxiing." The same wheels that serve for starting serve also for alighting; sometimes these are provided with brakes. Sometimes the machine has skids on which it alights and stops in a short distance.

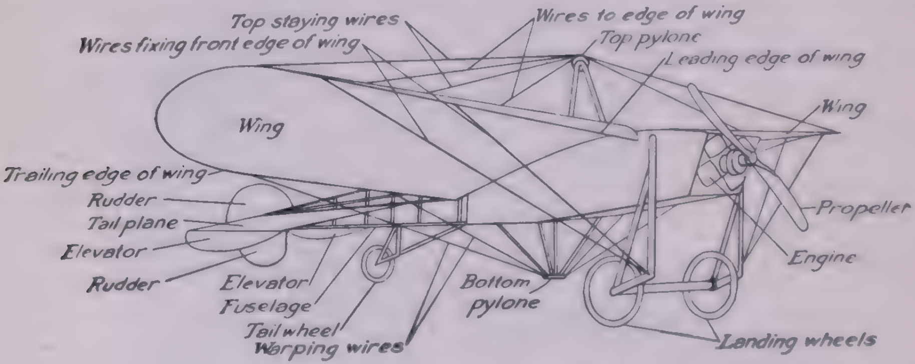

Fig. 117. — Bleriot monoplane

Running the airplane. For steering, there must be two sets of rudders — one to guide the plane up and down, and one to guide it to the right and left. The horizontal plane used for the first purpose may be placed either in front or at the rear. The vertical plane for the second purpose is placed at the rear. Both these planes are controlled by levers within easy reach of the aviator.

The direction of flight depends on the speed of the machine and on the angle that the planes make with the direction in which the machine is being driven. An increase in the angle or in the speed tends to make the machine rise; a decrease, to make it fall; hence, by the proper adjustment of speed and angle, the machine may be made to go in a horizontal plane. As the direction of the wind is constantly changing, the aviator must change the angle of the planes to correspond.

Airplanes easily tip from side to side on account of the variation in air currents on the two sides. This tendency to tip must be neutralized in some way by the aviator. This is most frequently done by warping the tips of the planes or through a motion of small flaps attached to the main planes. These are controlled by a lever, which connects with the tips by means of wires. They are so arranged that as the tip on one side is warped up, the tip on the other side is warped down. They can be so handled as to check the tendency of the machine to rock from side to side.

In making a turn, the part of the machine on the outside of the curve travels faster than the part on the inner side and so tends to rise. This tendency is controlled by warping the tips of the planes, just as in keeping the machine balanced in ordinary flight. In the first planes the aviator was exposed to the weather, but in the later ones enclosed cabins are provided.

Instruments on dashboard. The dashboard in an airplane looks something like that in an automobile, but is much more complicated. There are ten or more instruments, which register altitude, speed, direction, and rate of climbing. There are thermometers, pressure gauge, gasoline gauge, and compass, besides the controls by which the plane is run. One important recent invention is the earth induction compass, which enables the pilot to maintain his course unhampered by fog, snow, rain, or hail. The condenser altimeter is an instrument which enables a pilot to determine his exact height or his distance from any object that he may be approaching.

AIRSHIPS

Having noted the development made with airplanes — the heavier-than-air machines — we will next see what progress has been made in connection with airships — the lighter-than-air machines.

Early history of balloons. The first experiments with balloons were carried on in France. The first man to ascend in a balloon was M. de Rozier, who in 1783 rose to a height of about eighty-four feet, the balloon being held captive with ropes. This was made to rise by building a fire on a grate situated at the bottom of the balloon; as the air became heated, the balloon rose, bearing with it M. de Rozier, who kept the balloon in the air for about five minutes by throwing straw and wood on the fire.

About a month later another ascent was made by two men, and the balloon was allowed to go free with the wind. The men descended about five miles from the starting place, the journey taking about twenty-five minutes.

In less than a month after this, another ascent was made by two other Frenchmen in a balloon filled with hydrogen gas. The journey lasted about an hour and a half, and the men landed about thirty miles from the place from which they started. The first ascent in America was made during December of the same year. After this, experiments were carried on in other countries, and many improvements were made.

Why a balloon rises. The principle involved in the rise of the balloon is similar to that in the floating of a boat. It is much the same as though a diver in the water should set free a block of wood. It would at once rise to the surface because it is lighter than water. The balloon rises till it weighs the same as an equal volume of air around it, the air being lighter the higher up one goes. The balloon continues to float at this height and is carried by the wind till, as some of the gas escapes, it gradually falls to the ground. When the balloonist wishes to rise higher, he throws out sandbags which have been placed in the basket of the balloon; as a result, the balloon becomes lighter and rises. If the balloonist wishes to descend, he pulls a line opening a valve that allows the gas to escape, and then the balloon sinks.

DEMONSTRATION 45

Purpose. To illustrate the principle of the balloon.

Apparatus. Large-mouthed bottle; rubber stopper with two holes; thistle tube; zinc; hydrochloric acid; rubber tubing.

Directions. 1. Put some granulated zinc in the bottle. Bend a short glass tube at right angles and push one end through one of the holes in the stopper. Put a thistle tube through the other hole. Put the stopper in the bottle. Push down the thistle tube nearly to the bottom of the bottle. Add water till it rises to cover the end of the thistle tube. Push one end of a rubber tube over the end of the right-angled tube.

2. Make some soapsuds in warm water. Dip the end of the rubber tubing into the soapsuds.

3. Add hydrochloric acid through the thistle tube. Hydrogen will be generated and will pass out through the tube into the soapsuds. Remove the tube from the suds and allow a bubble to form on the end of the tube. Shake it off. Why does it rise? This same gas is often used to fill balloons.

4. Apply a lighted match to a floating bubble.

Dirigible balloons. The next great step in the development of air navigation was the appearance of the dirigible balloon, or airship. This was propelled by artificial means and steered by a rudder. The first attempts were not very successful, on account of the great weight of the engines used; and it was not until light engines of great horsepower were developed that much progress was made in air navigation.

The first successful journey in a dirigible balloon was made in France in 1884. Although this was a short journey of only two or three miles and return, it showed the possibilities in this kind of airship. During the last fifteen or twenty years great strides have been made in the development of airships.

Santos-Dumont. Santos-Dumont was the first man to attain any great success with airships. While he was a Brazilian by birth, he carried on most of his experiments in France. He began his experiments about 1898, and his many remarkable successes attracted much attention. One of the chief of these was his trip around the Eiffel Tower and return to his starting place.

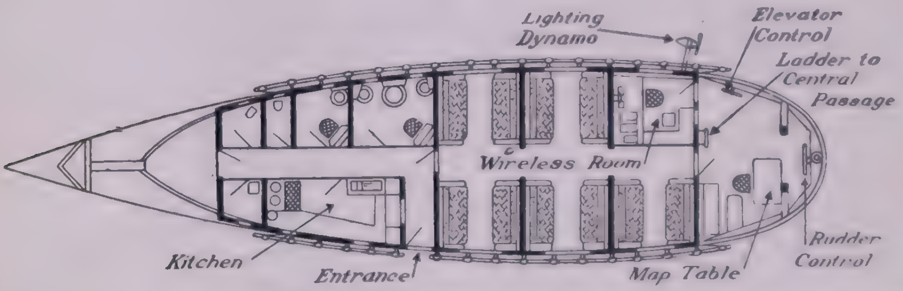

Fig. 118. — Section through passenger car of *Los Angeles*, which carries 20 persons

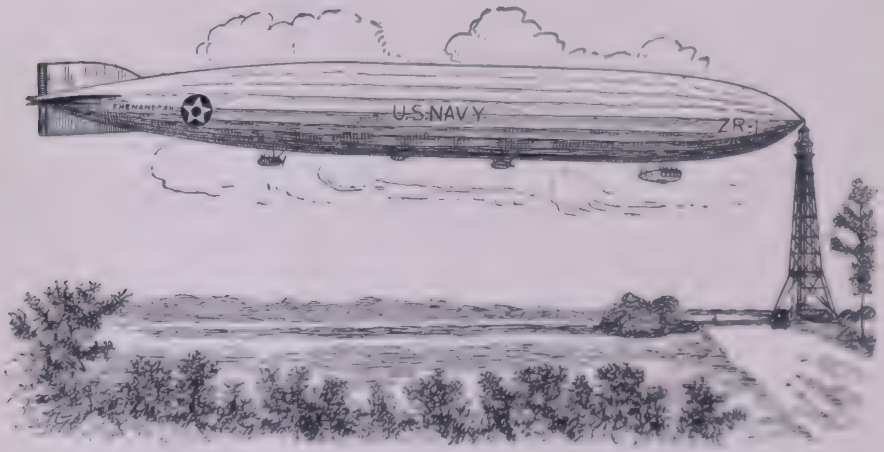

Fig. 119. — The *Shenandoah* moored to mast

Zeppelins. The best known of the rigid type of airships are those of Count Zeppelin of Germany, who began experimenting with airships about 1898. The success he attained afterward is well known the world over. He began the construction of airships of a gigantic size, much larger than had ever before been attempted.

The framework of the first Zeppelins was made of aluminum and divided into separate compartments, each of which contained a gas bag filled with hydrogen gas. Suspended from this frame were two boat-shaped cars between which was a weight running on a rail, by which the balance of the ship fore and aft could be adjusted. The ship was driven by means of four propellers, ten feet in diameter, each with three blades. These were turned by two powerful engines of 110 horsepower, one engine in each car.

At the rear end were two planes, which gave greater stability when the airship was traveling rapidly. Steering up and down was effected by means of elevating planes, and steering to the right and left was controlled by a triple rudder placed at the rear.

The Los Angeles. The largest of present-day Zeppelins, known as ZR3, was recently constructed in Germany for the United States and was brought to this country in 1924, where it was named the *Los Angeles*. This made a continuous flight from Germany to the United States, a distance of 5,060 miles, in eighty-one hours, at an average speed of sixty-two miles an hour. This is half the time required for the great steamship *Mauretania*. This airship is 656 feet long and ninety feet in diameter; it has a useful lift of forty-four tons. It is run by five powerful motors, each developing four hundred horsepower, and can attain a speed of seventy-five miles an hour. It has a capacity of thirty passengers and is equipped with modern conveniences similar to those found on a steamship.

This ship marks a distinct advance in two lines: first, in the material of which it is constructed, and secondly, in the gas used to keep it aloft. It is made of duralumin, which is an alloy made chiefly of aluminum and containing also copper, manganese, and magnesium. This alloy combines in a remarkable degree the qualities of lightness and strength. Its weight is only about one third that of steel.

The first airships made were kept up by means of hydrogen gas. This is so combustible when mixed with the oxygen of the air that it is dangerous, and mishaps in airships have often been due to the burning of this gas. In recent years another light gas, called helium, has been used in place of hydrogen. While it is not as light as hydrogen, it is noncombustible and so is much safer. Helium is rare and hence expensive. However, in recent years the cost has been greatly reduced through improved methods of manufacture.

Another advance made is the use of tall steel mooring-masts, to which the airships are fastened instead of being kept in huge sheds, known as hangars.

In England an airship even larger than the *Los Angeles* is being built. It is to be 695 feet long and 132 feet in diameter. It will carry 120 passengers and ten tons of freight and mail. It is to contain thirty-four berth cabins, a smoking-room, a kitchen, a dance hall, and many other conveniences. It will be run by seven engines, each with 550 horsepower.

Comparison of airplane and airship. In principle the two are entirely different. The airship is kept up because it is lighter than air, made so by the use of light gases. On the other hand, the airplane is heavier than air and is kept up by the resistance which its wings offer to the air as it is driven forward by the propeller.

In comparing the uses of the airship and the airplane, we find that each has its advantages. The airship is safer, can carry a much greater weight, and can stay in the air longer. On the other hand, the airplane can travel faster and is much smaller and cheaper to make. We might perhaps compare the airship with the freight train that carries heavy loads, and the airplane with the express train that carries lighter loads and travels faster.

COMMERCIAL FLYING

In Europe. The beginnings of commercial flying have been made, both in Europe and in this country. Some idea of the extent to which a business is made of flying will be given by the following figures. In the year 1922 thirty-six thousand persons and eight hundred tons of merchandise were carried by the various companies in Europe. In 1924 fifteen hundred passengers crossed the English Channel by air.

Between Paris and London a regular schedule is maintained by large planes, each carrying nineteen passengers and their baggage. The distance of 245 miles between the two cities is covered in about an hour and a half. Ten thousand miles of air lines in Europe now operate on regular schedules.

In the United States. At the present time there is very little commercial flying in this country. However, many indications point to a rapid development along this line in the near future.

Air mail. An outstanding accomplishment of the United States is its aërial mail service. In the summer of 1918 a regular aërial mail route was established between New York and Chicago. This has been extended to reach the Pacific Coast; and regular mail service is maintained between New York and San Francisco (a distance of 2,680 miles) and intermediate cities. Letters are carried between New York and San Diego in thirty-three hours. This cuts about seventy-five hours from the time required by a train for the transcontinental trip. One feature that has made this time possible is the provision made for night flying by the aid of lights placed along the way. At five of the larger centers are huge searchlights with five hundred million candle power, whose beams are visible

120 miles on clear nights. Between these are placed lights of lesser power.

In 1922 these planes flew nearly 2,000,000 miles without the loss of a single life. In 1923 they carried 65,000,000 letters, traveled more than 1,500,000 miles, and completed 96 per cent of eight thousand scheduled trips.

Fig. 120. — One of Uncle Sam's new aërial postmen

Lieutenant Culver, who started from Washington in the summer of 1918 in the first aërial mail flight.

Passenger service. The great advantage of air service is the saving of time, since flying is the fastest method of transportation known. It is often useful in emergencies. For example, a man in New York learned that his brother in Chicago was dying. He telephoned for an air taxi and in seven hours was at his brother's bedside.

It is estimated that in the three years 1921–1923 three hundred thousand flights were made in the United States, with a mileage of eight million miles, carrying three hundred thousand passengers, and transporting four hundred thousand pounds of freight.

Development of passenger-carrying service has been made along three lines: large "air buses," medium-sized taxis, and small flivvers. There has been organized an air Pullman company, which is having thirty "sky buses" made, each capable of carrying seven passengers and more than a ton of baggage. A number of cities have air taxis; one company operates forty-six air taxis in its district. Another possible line of development is a small plane that can be made at low cost, just large enough to carry one person. A number of planes of this type have been made. One of the smallest weighs 221 pounds, has a wing-spread of twelve feet and a height of six feet, can travel seventy-five miles an hour, and can go fifty miles on a gallon of gasoline. Another plane has been made which, with its wings folded, can pass through a ten-foot gateway.

Is flying dangerous? One thing that undoubtedly hinders the growth of commercial aviation is the fear people have of flying. Naturally on first thought flying seems dangerous. While, of course, flying has its dangers, probably these have been exaggerated. Most of the accidents have occurred, not in commercial flying, but in connection with dare-devil aviators who were doing stunts, or in connection with tests made by experts in the interest of science. The following figures give definite information as to just how dangerous flying is: In this country, in the three years 1921–1923, figures show that in regular fixed-base flying there was one accident for every 172,000 miles flown; one injury for every 220,000 miles; and one fatality for every 350,000 miles.

By means of a rough estimate we may make a comparison with the number of accidents occurring with automobiles. In 1923 there were about 15,000,000 automobiles in this country. If we assume that each car averaged five thousand miles of travel during the year, we get a total of 75,000,000,000 miles traveled.

Enough figures regarding automobile accidents are available so that the following estimates may be worked out:

COMPARISON OF ACCIDENTS IN AUTOMOBILES AND AIRPLANES

	NUMBER OF MILES TRAVELED		
	TO ONE ACCIDENT	TO ONE INJURY	TO ONE FATALITY
Automobile	50,000	200,000	5,000,000
Airplane	172,000	220,000	350,000

It appears from these figures that more accidents occurred with automobiles than with airplanes in proportion to the distance traveled, but that many more fatal accidents occurred with airplanes.

Miscellaneous uses. Besides transporting mail, passengers, and freight, airplanes have been put to other uses, such as taking photographs, delivering newspapers, patrolling forests to check fires, advertising by sky-writing, and spraying of insects. For this last purpose airplanes have been used successfully to fight the boll weevil, so destructive to the cotton plant. During 1924, more than three thousand acres of Louisiana cotton fields were dusted with poison to kill the weevils, and thus the crops were saved.

OUTLINE SUMMARY

AIRPLANES AND AIRSHIPS

I. Airplanes
    1. Early history of airplanes
        a. Langley's experiments
        b. Wright brothers
    2. Recent progress
        a. Distance
        b. Speed
        c. Length of time in air
        d. Height
        e. Weight carried

3. Construction of airplanes
    a. Types
    b. Shape of planes
4. Operation of airplanes
    a. How the plane remains in the air
    b. Stability
    c. Power
    d. Starting the plane
    e. Running the plane
    f. Instruments on the dashboard

II. Airships
1. Early history of balloons
2. Why a balloon rises
3. Dirigible balloons
    a. Work of Santos-Dumont
    b. Zeppelins
        (1) The *Los Angeles*
4. Comparison of airplane and airship

III. Commercial flying
1. In Europe
2. In the United States
    a. Air mail
    b. Passenger service
    c. Is flying dangerous?
    d. Miscellaneous uses

QUESTIONS FOR CLASS DISCUSSION

1. Which seems to have greater possibilities for the future, the airship or the airplane?
2. How does the airman control his airplane?
3. How are airplanes kept from tipping?

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CHAPTER XX

THE TELEGRAPH

1. What are the essential parts of a telegraph system?
2. How do they work?

USES OF THE TELEGRAPH

There are many wonderful machines, very important in our daily lives, to which we have become so accustomed that we hardly realize what they do for us. Such a machine is the telegraph; let us stop for a moment to see how much we owe to this wonderful little instrument. We are apt to think of the telegraph only in connection with bringing the sad news of the death or sickness of a friend or relative. But this is only an occasional use. We receive the benefit of the telegraph every day of our lives, many times unconsciously. Many of these services which formerly were rendered only by the telegraph are now being performed also by the radio.

Newspapers. Each day the newspaper brings to our doors news which has been flashed from every part of the world by the telegraph. When the President makes a speech in any part of the United States, the next day's papers give the entire speech to all parts of the country. As one looks over the items of a daily newspaper, it will be found that the great majority of the items, outside the local news, have been sent in by telegraph.

Elections. On election day citizens in all parts of the country cast their ballots. By midnight of the same day returns are telegraphed in to headquarters; even in presidential elections, by the next morning the whole country usually knows who has been elected.

Weather forecast. Each day's paper contains the forecast of the next day's weather. This is made possible because reports of weather conditions in two hundred localities are telegraphed to Washington and other cities, where forecasts of weather are made, based on these reports.

Railroads. The telegraph is necessary in the running of railroad trains. As explained in Chapter XV, whenever a train arrives at a station the news is telegraphed to a man called a dispatcher, located at headquarters, who arranges the places where the trains shall meet and pass, thus avoiding accidents.

Electric clocks. Clocks may now be regulated by electricity. A certain accurate clock is taken as the standard; other clocks, connected with this, have a device by means of which the minute-hand is set so as to make the clock agree with the standard time.

Other uses. The telegraph is of great value to the business man in his ordinary transactions. If he wishes to order some material that he needs at once, he can telegraph and the order will be sent by the next train. If a great flood or fire destroys a city and leaves the people destitute and homeless, the telegraph sends out the news, and relief comes back at once.

Compare the conditions today with those a hundred years ago, when there were neither railroads nor telegraphs. The battle of New Orleans, in the War of 1812, was fought after the treaty of peace had been signed, because the news traveled so slowly that the soldiers had not yet learned that the war was ended.

HISTORY OF THE TELEGRAPH

The inventor. On May 24, 1844, the now famous words "What hath God wrought?" were sent by telegraph from Washington to Baltimore, a distance of forty miles. The credit for the achievement of being the first to send messages this distance belongs to Samuel Morse. Back of this success, however, is a story of struggle, poverty, and perseverance. Samuel Morse was a professor in the University of the City of New York, and he gave his spare time to a study of electricity. In 1832 he conceived the idea of conveying signals at a distance by means of electricity. He worked for eleven years in perfecting his instrument, which was finished in 1843. He then invented a system of dots and dashes for sending messages. During this period he deprived himself of many comforts in order to get enough money to carry on his experiments.

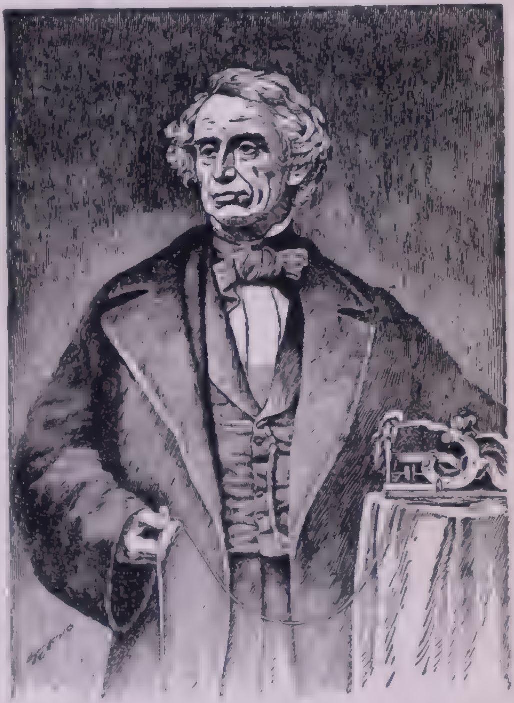

Fig. 121. — Morse and his first instrument

Before this, many experiments had been tried by other men in sending messages by electricity; some had been partially successful, but none of them had suggested any possibility of commercial success. Morse's success was made possible only through the inventions of other men, whose results he put together in the construction of the telegraph. Two of the most important of these were the invention of the electric magnet and the invention of a constant battery to furnish electricity.

Morse made application to Congress for aid to build a telegraph line between Washington and Baltimore. He was finally successful in this appeal and in 1843 he received an appropriation of thirty thousand dollars. With this, a line between the two cities was constructed and the first message was sent.

This first line proved so successful that the telegraph was soon in use in all parts of the world. By 1861 a line had been built connecting New York and San Francisco.

Today there is a network of telegraph lines extending over the whole country. In 1922 there were 253,000 miles of line (equal to the distance to the moon) and 1,853,000 miles of wire. It was estimated that there were 191,000,000 messages sent out, or about one and two-thirds for every person in the United States.

Atlantic cable. A great step in advance was taken through the laying of the Atlantic cable in 1857 from Newfoundland to Ireland, by means of which messages were sent across the ocean. The credit for laying this cable is due largely to Cyrus W. Field. After the cable had been used successfully for eighteen days, however, it ceased to work. At the close of the Civil War, Mr. Field determined to lay another cable. He started out in 1865 with 2,300 miles of cable on board the *Great Eastern*, at that time the largest vessel in the world. About a thousand miles from starting, the cable parted, and it could not be found again. In the following year (1866) another attempt was made, which proved successful. From that time there has been telegraphic communication between America and Europe. In 1922 there were 76,000 nautical miles of ocean cable.

How the Telegraph Works

While some improvements have been made in the telegraph since Morse's day, yet in principle the telegraph in use today is the same as that invented by Morse. The telegraph consists of four parts: the sender, or key; the sounder; the relay; and the batteries. Figure 124 shows how these various parts are arranged.

The key. The structure of the sender, or key, is shown in figure 122. The key includes a lever with a button at one end. On the under side is a point which makes contact with another point directly beneath it. These two points are ordinarily separated by the upward pressure of a spring. When the key is not in use, a switch, which forms part of the key, is shut so that the circuit is closed. When the key is to be used, the switch is opened. When the button is pushed down, the two points come in contact and the current passes through, thus affecting the relay and the sounder at the other end.

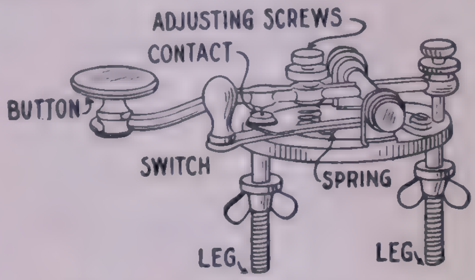

Fig. 122. — Telegraph key

The sounder. The sounder is shown in figure 123. This consists of an electromagnet, and over this a bar, fastened at one end, to which is attached an armature. Ordinarily the bar is kept back by a spring so that the armature is at the maximum distance from the pole-pieces of the electromagnet. The distance that the bar can be pulled down towards the poles of the electromagnets is controlled by a screw. When the key of the sender is closed, the current passes over the telegraph wires and through the electromagnet of the sounder, which becomes magnetized, thus pulling down the armature. When the key is open the current ceases to flow over the telegraph wires and through the electromagnet coils, so that these are no longer a magnet, and hence the armature is pulled back by the spring. Thus two sounds are made — one when the armature is drawn down, and another when it is

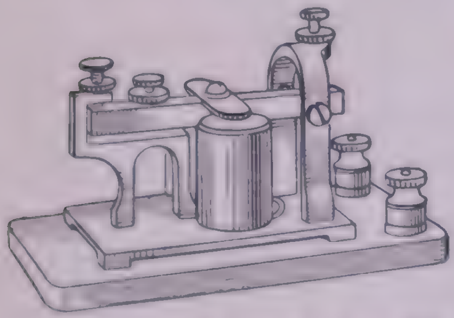

Fig. 123. — Telegraph sounder

released by the striking of the bar against the screws which limit the bar's travel.

Morse alphabet. When these two sounds come very close together, so that they seem as one, the signal is called a dot. Where they are separated by an appreciable time, so that two distinct sounds are heard, the signal is called a dash. The different letters are represented by various combinations of dots and dashes. The American code of the Morse alphabet is as follows: A ·— B —··· C ·· · D —·· E · F ·—· G ——·
H ···· I ·· J —·—· K —·— L —— M —— N —· O · ·
P ····· Q ··—· R · ·· S ··· T — U ··— V ···—
W ·—— X ·—·· Y ·· ·· Z ··· · & · ···

These dots and dashes may be recorded on a strip of paper run by clockwork, which passes under a writing point attached to the sounder. When the key is held down for a dash, a longer mark is made on the paper than when the key is held down for a dot. However, the telegraph operator can learn by practice to read the signals by ear and write them down directly as fast as they come in. Telegraph recorders are seldom used today.

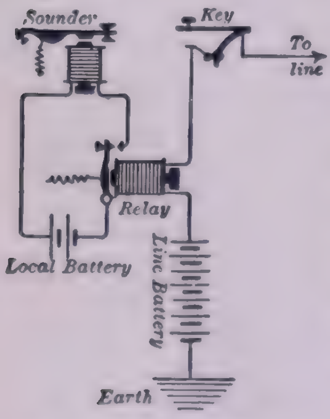

Fig. 124. — Diagram of relay telegraph circuit

If the two stations are only a short distance apart, the sender, the sounder, and the batteries are all that are necessary for sending and receiving messages. But when the stations are long distances apart, the wire offers so much resistance that the sounder is worked only very weakly or not at all, so that no signals are transmitted.

The relay. To overcome this difficulty, a relay is used. The method of connecting this is shown in figure 124. There are two distinct circuits: first, the long distance circuit which operates the relay; and second, the local circuit which operates the sounder. In the long distance circuit only one wire is needed, as the ground serves as another conductor through which the current returns. The ends of the main line are attached to pieces of metal sunk in the ground so as to make good connections. The relay (figures 124 and 125) is somewhat like the sounder, but far more delicate and therefore operating with very weak currents. It consists of an electromagnet and an armature. When a current passes through the electromagnet, the armature is drawn towards the poles of the electromagnet, and contact between two points is made. This closes the local circuit and brings into play the local battery which operates the sounder. By means of these relays, telegrams may be sent long distances, even across the continent. The message may be sent to a city, as from New York to Chicago, and then the message may be repeated, as from Chicago to San Francisco.

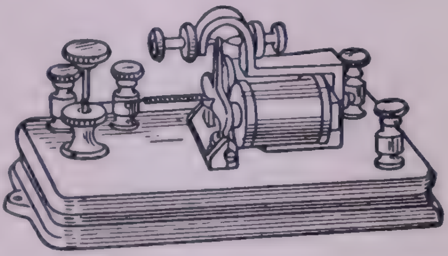

Fig. 125. — Telegraph relay

DUPLEX TELEGRAPHY

When the telegraph was first used, only one message could be sent at a time over the wire; but in a few years the system of duplex telegraphy was invented, by means of which two messages could be sent at the same time in opposite directions. Then, later, it became possible to send two messages in the same direction at the same time on one wire. The next development allowed two messages to be sent from each end of the line at the same time, or four in all. And finally we have a device by means of which many messages can be sent in both directions at the same time. It has been found possible to send thirty-six messages in each direction at the same time. In actual practice, however, it has been found best to limit this to six in each direction. For this work twelve operators are needed at each end, six to send and six to receive; one line may thus employ twenty-four operators. There is a separate key for each sender and a separate sounder for each receiver.

HIGH-SPEED TELEGRAPHY

When it is desired to transmit long messages for newspapers, the hand method of sending would be too slow. For this purpose machines are used which send messages with great rapidity. Several systems are able to send four hundred words per minute. In one system words have been sent at rates varying from a thousand to three thousand words per minute. This is much more rapid than even the telephone.

The words of the message are first translated into the Morse alphabet, and holes are made by a machine on a strip to correspond to the dots and dashes of the alphabet. This work is done by a machine much like a typewriter, each key of which makes the holes that correspond to the dots and dashes for its letter. This strip of paper is run through telegraphic instruments so arranged that the signals are transmitted to the other end of the line.

Various means are used to receive these messages. One of the most common is a paper covered with certain chemicals which are broken up by the electric current and leave markings on the paper. One combination used is starch and potassium iodide. When this salt is broken up, the iodine is set free; and when it comes in contact with the starch, it produces a blue color. In another device an instrument is so arranged that moving mirrors reflect a ray of light upon a strip of sensitive photographic paper. A machine is now in use which copies the message in typewritten form, ready for instant delivery and use. This machine has made a record of a hundred words a minute.

FACSIMILE TELEGRAPHY

Devices are now used which make it possible to transmit accurate copies of charts, diagrams, pictures, and signatures over a telegraph line. This is called facsimile telegraphy. If a person takes a pen in a telegraph office and writes a message, it is possible to reproduce it so accurately at the other end of the line that the handwriting may be recognized. Thus it is possible for a person to telegraph his signature to a check or other paper requiring a personal signature. This is called the writing telegraph.

By means of the printing telegraph, messages may be sent so that they are received printed on a strip of paper. The stock ticker, which is one form of the printing telegraph, is very widely used among brokers.

DEMONSTRATION 46

Purpose. To show how a set of telegraph instruments works.

Apparatus. Sounder; sender; relay; cells.

Directions. Connect the parts of the telegraph instruments, including the relay, as shown in figure 124. Study each part carefully to see how it works. Make a drawing showing the connections. Try sending some of the letters of the Morse alphabet.

OUTLINE SUMMARY

THE TELEGRAPH

I. Uses of the telegraph
    1. Newspapers
    2. Elections
    3. Weather forecasts
    4. Railroads
    5. Electric clocks
    6. Other uses

II. History of the telegraph
    1. The inventor
    2. Atlantic cable

- III. How the telegraph works
  - 1. The key
  - 2. The sounder
    - *a.* Morse alphabet
  - 3. The relay
- IV. Duplex telegraphy
- V. High-speed telegraphy
- VI. Facsimile telegraphy

QUESTIONS FOR CLASS DISCUSSION

1. What part does the telegraph play in our daily life?
2. What has been the history of the development of the telegraph?
3. How can the parts of a telegraph system be used to send a message?
4. How are messages sent at high speed?

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CHAPTER XXI

THE TELEPHONE

How does the telephone differ from the telegraph?

USES OF THE TELEPHONE

Number of telephones. Of all the remarkable inventions of the last century, probably no other has become quite so directly connected with the daily life of so many people as has the telephone. It has greatly modified our ways of living and of doing business. During the last twenty-five years there has been a remarkable growth in the number of telephones in use. In 1902 there were 2,371,000 telephones in the country; in 1924 there were seven times as many, or over fifteen million, or one telephone to every seven inhabitants, or about one to a family and a half. It has been estimated that about forty-two million messages are sent daily, or an average of three to each telephone, or of a thousand in a year. In 1922 there were 37,266,000 miles of wire, or enough to reach more than one third of the distance to the sun.

Uses in business. The telephone finds a place in almost every walk of life where the human voice is used. Large hotels are equipped with a complete system of telephones. Stores of all descriptions receive a large share of orders by telephone. When Benjamin Franklin was postmaster-general at Philadelphia, it required at least three weeks to send a letter by mail to Boston and receive an answer. Now the two cities are connected by telephone, and one may in less than five minutes transact business which required three weeks, or five thousand times as long, a century ago.

Factories and mines are equipped with telephones which allow the work to be controlled from a central office. Some railroads are now using the telephone in place of the telegraph in dispatching trains.

Many of the larger newspapers are equipped to gather news by telephone instead of telegraph. For every edition of the New York *World*, there has been an average of 750 telephone messages. The United Press has worked out a method by means of which news is telephoned at one time over one wire to ten or twelve newspapers situated in as many different towns.

In emergencies, as in cases of sickness, fire, or burglary, the telephone is of special value. In our large cities it is possible to reach the entire police force by use of a system of telephones. In times of war a string of telephone wires enables the generals to control the actions of their soldiers.

Telephones on farms. There has been a great increase of the use of the telephone on farms, and it is doing much to lessen the loneliness of farm life. Every fourth farmer has a telephone which puts him in touch with his neighbors and markets. The telephone is of great aid to the farmer in marketing his produce, especially his perishable crops. It is of special value also in calling for help in case of emergency. For example, in 1909 a three million dollar fruit crop was saved in Colorado by use of the telephones. One spring when the trees were in flower the owners learned from the Weather Bureau through the telephone that a frost was coming that night, which would injure the blossoms. The farmers telephoned to the towns for help to come and assist in lighting fires to ward off the frost. In this way the crop was saved.

Effect of the telephone. The telephone has had a most important effect on the development of the country and on the spirit of its people. It has been the climax of those recent inventions that have helped to bring people closer together.

Railways and steamboats carry letters, the telegraph transmits messages instantly, and finally the telephone, which brings men practically face to face, carries speech over the electric wire, and makes both message and answer instantaneous.

HISTORY OF THE TELEPHONE

The inventor. The inventor of the telephone was Alexander Graham Bell. He was born in Scotland, and he moved to Canada when he was twenty-three years old. Two years later he moved to this country and became a professor in Boston University. For several years he worked on his idea of some method of direct communication at a distance by means of the voice. In 1876 he finally succeeded in making an instrument that would carry the human voice, and on this instrument he immediately obtained a patent. In the same year he exhibited it at the Centennial Exhibition at Philadelphia, where it received much praise and attention. At first it was generally regarded as a toy without practical application. In getting the telephone started as a commercial proposition, Bell and his friends who were financing the undertaking had considerable difficulty.

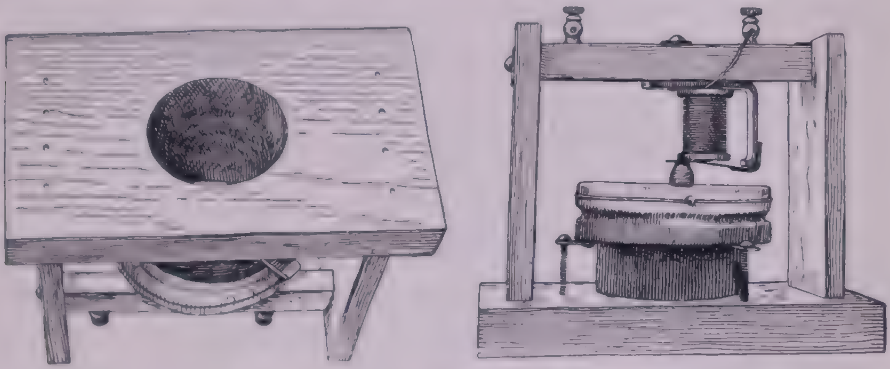

Fig. 126. — First Bell telephone

Commercial growth. The first public telephone line was installed in 1877 in the state of Massachusetts, and by the end of the year there were 778 telephones. It was not until 1880 that the Bell Telephone Company was well established. At first the telephone could be used only over short distances, but improvements were made so that it could be used over longer distances. The first intercity line was built between Boston and Lowell. A few years later Boston and New York were connected by telephone; in 1893 New York and Chicago; and still more recently conversation has been carried on between Boston and Denver, a distance of about 2,500 miles, and finally between New York and San Francisco, a distance of about 3,500 miles.

Periods of the telephone. The history of the telephone may be divided into four periods. The first period, from 1876 to 1886, was one of experiments. The instruments used were very crude and imperfect. Iron wire, poor transmitters, overhead wires, and boy operators were used.

The second period, from 1886 to 1896, was one of development. During this period great improvements were made and the telephone reached a high degree of efficiency. Copper wire, underground cables, long distance lines, and girl operators were innovations of this period.

The period from 1896 to 1906 was one of expansion. This was the period of business, during which profits were made as a result of previous toil and investments. In this period there appeared the pay station, the farm line, and the private branch exchange.

The period from 1906 to 1916 was one of organization. During this period the telephone has reached out into ever broadening fields till it has become truly national in scope.

HOW THE TELEPHONE WORKS

Comparison with telegraph. Having seen something of the history and uses of the telephone, let us now try to understand how it is constructed and how it works. Like the telegraph it uses electricity, yet in principle it is quite different. In the telegraph the circuit can be opened and closed and the signals sent in this way; while in the telephone a current is passing through the wire all the time, and the voice causes variations in the strength of the current. It is an electric current, and not sound waves, that travels along the wire.

With the telegraph, the earth can be used as a return wire, thus saving the expense of one wire; but with the telephone two wires are generally used, because the telephone is so sensitive that various disturbances that develop in the earth interfere with its working.

Receiver. In the simplest form of telephone first used, one piece of apparatus served as both transmitter and receiver. Figure 127 shows the construction of this. It consists of a U-shaped magnet which has around each pole a coil *C* of many turns of very fine wire which is connected with the outside circuit. Just in front of the magnet is a thin diaphragm *D* made of thin sheet iron. As one speaks into the transmitter, the air waves produced by the voice cause the diaphragm to vibrate back and forth. This vibration across the magnetic field of the magnet causes a current of varying strength to be set up in the coils, the amount of current depending on the distance the diaphragm moves. These varying currents travel to the other end of the line and cause the magnet of the instrument at that end to attract the diaphragm and give it the same motions as those of the first diaphragm which started the variations in the current. In this way the second diaphragm makes

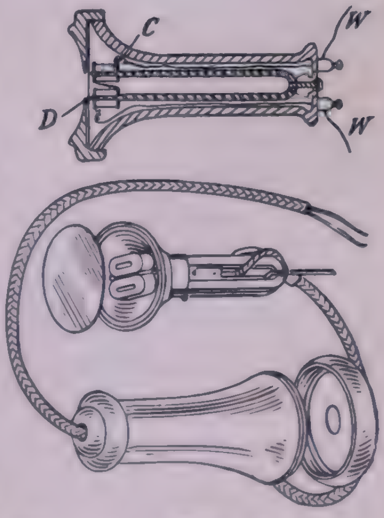

Fig. 127. — Bell telephone receiver

the same vibrations as the first, and hence it reproduces the same sounds. This form of telephone can be used for short distances only.

The modern telephone has been modified in several ways. In the first place, another instrument has been introduced to serve as the transmitter. The receiver is about the same as that first used, except that a U-shaped magnet is used in place of a single magnet.

Carbon transmitter. The carbon transmitter is the form most commonly used (figure 128). Back of the diaphragm *D* is some granular carbon *G* in a little cup *C*, and as the diaphragm vibrates, it causes a variation in the pressure upon the grains of carbon. This produces a variation in the strength of the current that passes through the battery and the primary winding of the induction coil *Ic* (figure 129), and produces in the secondary coil varying currents, which travel over the main line. These variations are reproduced in the receiver at the other end and produce corresponding variations in the vibrations of the diaphragm.

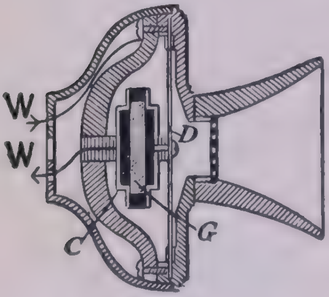

Fig. 128. — Carbon transmitter

The induction coil just referred to is another addition to the original telephone. This is necessary in order to produce a current of sufficient force to operate over long distances. The current is usually furnished by a battery at the central station, instead of by a local battery at the telephone.

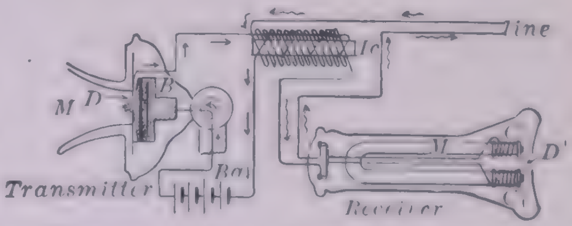

Fig. 129. — Local battery telephone system

The telephone is a very sensitive instrument. In some cases the distance through which the diaphragm moves is only one ten-millionth of an inch. To send a telephone message requires less than a hundred-millionth part of the current required for a telegraphic message. So small is the amount of current necessary to operate the receiver that if all the work done in lifting the receiver off the hook one foot were changed into electric energy, it would furnish enough electricity to operate the receiver continually for a hundred thousand years.

DEMONSTRATION 47

Purpose. To study the working of the telephone.

Apparatus. Galvanometer; bar magnet; coil of wire wound in form of a spool; demonstration form of telephone that can be taken apart.

Directions. 1. Secure a coil of wire wound on a spool and provided with binding posts. Connect these with a galvanometer. Place a bar magnet inside the coil. Bring a piece of soft iron near the magnet. Does the needle move? Take the iron away. Is any current generated?

2. Make a study of the parts of a telephone. Make a drawing and explain the use of each part.

CENTRAL

One of the most interesting parts of a telephone system is the central station, where connections are made for different subscribers. When a subscriber takes his receiver from the hook, a little lamp glows opposite the hole or jack that is marked with this person's number on the switchboard; this is a signal to the operator that someone wishes a connection made.

The operator's receiver and transmitter set are fastened to her head and neck, so that both her hands are free. She connects her set with the subscriber's by means of a plug inserted into the calling subscriber's jack, and, having learned the desired number, makes the necessary connections. This is done by inserting a second plug associated with the first plug connecting with the first subscriber's telephone into a jack connecting with the second subscriber's telephone, causing two small lights associated with the plugs in use to glow.

By pressing a button associated with the plugs in use, she causes a bell to ring on the second subscriber's telephone. The lights associated with the plugs then go out. The bell continues to ring automatically as long as the first subscriber keeps his receiver off the hook or until the person called answers. When subscribers hang up their receivers, the lights associated with their plugs in front of the operator glow again. Then when the operator pulls out the plugs, the lights go out.

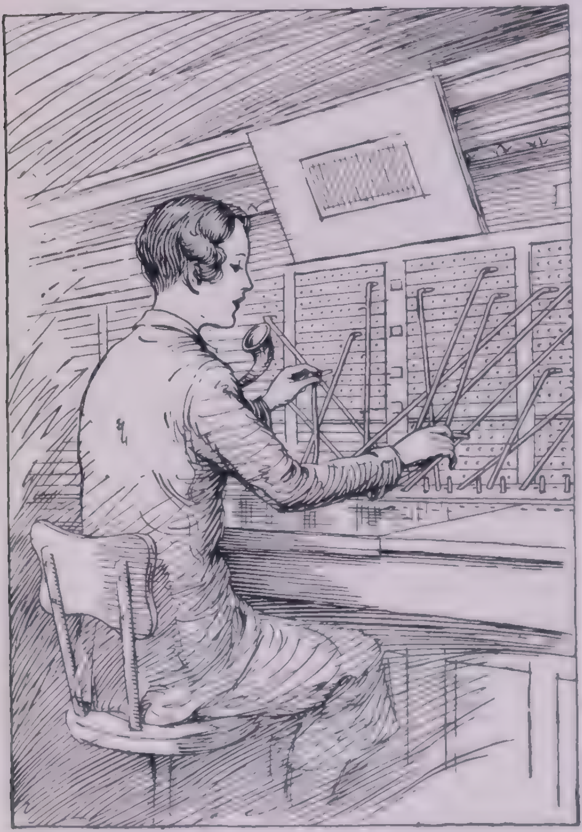

Fig. 130. — Central making connections

Each dot on the board is a subscriber's connection. The cords connect one subscriber with another. The switches for operator's phone and the pilot lamps showing when a subscriber wishes a connection are set in the table.

The cords connected to the plugs containing the connecting wires are weighted and hung below the switchboard so that when the plugs are taken out of the jacks the cords fall back into their places automatically, out of the way and ready for the next call. Practice enables the operators to work with astonishing rapidity. In the best exchanges they answer a call in an average time of three seconds.

For out-of-town calls, connection is made with "Long Distance," who makes the connection in much the same way as that already described. A record of the time occupied by the conversations is kept by means of an automatic time stamp. Charges are made according to the time that the line is in use.

FIELD EXERCISE 6

Purpose. To visit the central telephone office.

Directions. Arrangements can usually be made with the superintendent of the telephone exchange to allow the class to visit the central office. Here someone can explain the work of the operators and the construction of the central telephone outfit. At the next meeting of the class the points observed should serve as a basis for discussion.

SOME RECENT DEVELOPMENTS

Use of vacuum tube. Improvements are constantly being made in the telephone. The Bell Telephone Company employs several hundred experts who devote their time to experimentation in order to find possible improvements. One of the more recent improvements is that the vacuum tube, so widely used in radio, is also being used in telephone practice for long distance telephoning, somewhat as the relay in the telegraph is used. When the current, through traveling long distances, becomes weak, its strength may be amplified by means of the vacuum tube, and thus conversation may be carried on over long distances.

Automatic telephone. Another recent innovation is the automatic dial telephone. The subscriber rotates a dial in a certain way according to the number he wants, and the connections are made automatically by machines that take the place of the central operator. While this kind of telephone is more complicated to work, so far as the subscriber is concerned, it has been found that connections can be made more quickly than by the ordinary method with operators.

Carrier current telephone. This is the name given to the method by which it has been found possible to send several telephone messages over one wire at the same time and also to send both telephone and telegraph messages. At the receiving end these messages are separated by tuning devices similar to those used in radio. Telephone messages have been sent over trolley wires without interfering with the usual service of the line, and also over high-tension power transmission lines.

Photos by wire. During the spring of 1925, transmission of photographs over telephone wires 3,600 miles long was tested and declared to have been a complete success. Seven minutes were required for each print. While the demonstration was in progress, a photograph was taken of the machinery and a group of spectators. The film was developed and ready for transmission within half an hour, and seven minutes later duplicates were in three cities. At the time when these photographs were being sent, the wires were being used also for ordinary telephone conversation.

OUTLINE SUMMARY

The Telephone

I. Uses
    1. Number of telephones
    2. Uses in business
    3. Uses on farms
    4. Effect of the telephone
II. History of the telephone
    1. Inventor
    2. Commercial growth
    3. Periods
III. How the telephone works
    1. Comparison with telegraph
    2. Receiver
    3. Transmitter
IV. Central
V. Some recent developments
    1. Use of vacuum tube
    2. Automatic telephone
    3. Carrier current telephone
    4. Photos by wire

QUESTIONS FOR CLASS DISCUSSION

1. Which is more useful to man, the telegraph or the telephone?
2. What has been the history of the development of the telephone?
3. How are the receiver and the transmitter constructed?
4. How are the connections made at central?

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CHAPTER XXII

RADIO

In what ways is radio different from the ordinary telephone?

Science has given us so many marvelous inventions that it is difficult to pick out any one as being the most wonderful. However, just at the present time none seems to appeal to the imagination of the American people quite so much as radio. The marvel of its use was well illustrated in the late summer of 1924 when that final exciting baseball game was being played between the Giants, of New York, and the Senators, of Washington, with the world's championship at stake. Scattered throughout the length and breadth of the whole country were groups of baseball fans gathered in front of radio loud speakers. These thousands of listeners were able to follow, inning by inning, play by play, and even down to the strikes and balls called on the batter, all the details of that thrilling game.

And still more recently we had another illustration of its magic on March 4, 1925, during the inaugural ceremonies at Washington. Millions of people throughout the United States were gathered in homes, halls, and schools to listen to the ceremonies. These millions of listeners heard the announcer on the steps of the capitol at Washington describe the things he saw: the arrangement of the platform and seats, the size of the crowds, and the kind of weather; we were informed when the members of Congress came from the capitol and took their seats in the stands, and finally when the President came upon the platform. Then as we listened, we heard Chief Justice Taft administer the oath of office to Calvin Coolidge, and then directly afterward we heard the President begin his inaugural address, which he delivered to the largest audience that any man ever addressed, estimated to have numbered twenty-two millions. The voice of a man speaking at Washington was heard in almost every nook and corner of the entire country.

In recent years radio is competing with the moving pictures as one of the popular sources of recreation of the American people. A conspicuous feature of radio has been its remarkably rapid growth within a few years. Only a short time ago, radio was of interest only to scientific experimenters; today it is a common topic of conversation everywhere.

In 1924 there were a thousand newspapers carrying radio programmes and radio news departments, twenty-five hundred country weeklies that featured radio, fifty magazines with radio sections, fifty exclusively radio periodicals, and 250 popular and technical books on radio.

It is very difficult, if not impossible, to find out exactly how many radio receiving outfits are in use, but estimates have been made that they probably number three or four millions and that the listeners number from ten to twenty millions.

USES OF RADIO

Uses in connection with receiving sets. The various uses to which radio is put are constantly increasing. Radio serves for broadcasting concerts, lectures, sermons, church services, dance music, weather forecasts, crop and market reports for farmers, bedtime stories for children, speeches in political campaigns, talks on all sorts of topics, news of the day, official time signals, reports of prize fights and of baseball games, and so on almost indefinitely.

Radio link. Radio is used also in connection with the ordinary telephone in what is called wired-wireless communication. A person speaks into an ordinary telephone transmitter, the electric impulses are carried through the wire to the other end, then travel by radio to some islands, and are finally received on an ordinary telephone. Thus the radio becomes an aid to the wired telephone. When used in this way, the radio telephone is known as the radio link. A practical commercial link of this kind was set up between Los Angeles and Catalina Island, situated about thirty-one miles from the mainland. Subscribers on the mainland had connections made with the island and talked as with the ordinary telephone. However, this system was finally replaced by a telephone cable, although it proved the practicability of the radio link.

Miscellaneous uses. Especially valuable is the use of radio on airplanes and steamships, where the wired telephone cannot be used. The radio compass has been used to guide ships. Some other possible applications of radio which at present are in the experimental stage are radio control and the transmission of power by means of radio. Radio control suggests great possibilities for the future. Progress has been made along three lines: with boats, with airplanes, and with automobiles, giving us the crewless ship, the pilotless airplane, and the chauffeurless automobile. The principle in all cases is the same. These objects are controlled from a distance by radio. The motive power in each case is self-contained; radio simply controls this power and steers the moving object. For instance, in the experiments with boats radio was used to start or stop the motor or make it go at half speed, and the rudder was moved so as to steer the boat either to the right or to the left. Navies have made application of this principle, and even a large ship like the U.S.S. *Iowa* was controlled in this way.

The principle involved in the control of airplanes is the same. In one experiment conducted by army officers, a man flew back and forth many times over Long Island as a passenger in a speeding plane guided entirely from below by radio, his hands not touching the controls. The possibilities of using radio-controlled airplanes in war as a means of dropping gas bombs on cities are self-evident.

The experiments with transmission of power by radio have not so far met with much success. Just at present the outlook in this direction does not seem to hold out much promise. Among the more recent accomplishments are the sending of finger prints, photographs, and written messages by radio.

In the month of May, 1924, photographs were sent by radio and telegraph from Honolulu to New York, a distance of more than five thousand miles. They were transmitted by radio across the Pacific Ocean to California. Here they were relayed for a short distance to a transmitting station, from which they were sent by radio across the continent to Long Island. The telegraph was used for short distances at the beginning of the process, at the relay station in California, and, at the end of the journey, from Long Island to New York.

Some Principles Underlying Radio

While the study of radio when carried out in all its details is extremely difficult and complicated, yet some of the simpler principles underlying radio any amateur can comprehend. The purpose of this chapter is to explain some of these principles. If you know something about the general principles of radio and how the different parts work, you will enjoy more the use of the radio which, perhaps, you may have in your home.

One feature about radio that makes it seem mysterious and difficult to understand is that communication by radio is carried on without wires. This feature seems unusual because we have become accustomed to thinking in terms of the wire used in the ordinary telephone and telegraph.

However, instead of starting with these, let us begin from another viewpoint — namely, the transmission of light from the sun. Light comes to us from this body, a distance of nearly a hundred million miles, without wires or any connecting link that we can see. We have become so accustomed to this fact that there seems nothing strange about it. Now, there is really nothing more strange about the transmission of radio signals than about the transmission of sunlight. In fact there is very much similarity between them, scientists tell us. Both travel at the same speed, 186,000 miles a second; and they both travel by means of similar waves which differ chiefly in length.

In past years scientists have assumed the existence of a substance called ether which was supposed to fill all space, and this ether was believed to be the medium through which light waves and radio waves travel. At the present time, however, some scientists doubt the existence of this ether. It will not be worth while for us to enter into a discussion of the question here; but whether ether exists or not, the belief that electricity and light are both transmitted by a wave motion remains unchanged.

· Perhaps the matter of wave motion can be made clear by a simple illustration. If you throw a stone into a pond, waves of water spread out in every direction; and the motion may be transmitted to a piece of wood floating on the pond a long way off. In radio the transmitting station may be likened to the stone; the ether and its waves, to the water and its waves· and the receiving apparatus, to the chip of wood.

To find the length of a water wave, we measure from the crest of one wave to the crest of the next wave. In a similar way the length of the ether waves in radio is measured. It is found that these ordinarily vary in length from five meters (sixteen feet) to thirty thousand meters (eighteen miles). Experiments have been conducted with waves less than an inch in length. Light waves are very short, being only about one ten-millionth of an inch in length.

The number of waves sent out by a transmitting station varies from a few thousands to several millions per second. There is a definite relation between the length of the waves and their frequency: the shorter the wave, the greater the frequency. For example, a wave length of two hundred meters represents a frequency of 1,500,000 per second, while a wave length of ten thousand meters represents a frequency of only thirty thousand per second.

BROADCASTING STATIONS

Since the beginning of all radio programmes is the broadcasting station, we will first study briefly the methods by which broadcasting is done. The essential parts of a broadcasting station are the transmitter, the modulating apparatus, and the aërial. The transmitter generates the radio waves; by means of the modulating apparatus these waves are changed in their character in accordance with the music or speech of the performer. The aërial generally consists of three or four wires insulated entirely from the ground. From this aërial the radio waves are given off to the surrounding ether.

The performer sings or speaks into a microphone, the round type being the one almost universally used. Certain parts of this instrument move, and these movements cause variations in the currents passing from the microphone to the transmitter. These currents are very weak and are magnified greatly by means of vacuum tubes before reaching the transmitter.

The purpose of the transmitter is to set up waves, which are carried in every direction and may be intercepted by the various receiving stations. These waves are started by means of very powerful electrical disturbances at the transmitting end.

One of the simplest ways in which these radio waves may be set up is through the use of a spark coil, similar to the type used in the automobile ignition system. Another way is by the use of an alternating current made by a dynamo specially built to produce a large number of vibrations.

However, the method now most commonly used employs the vacuum tube as a part of the apparatus. First, there is a source of a direct current at a high voltage. The vacuum tube acts as an interrupter of the circuit, much like a spark coil. Thus an alternating current is produced, and waves of very high frequency of vibration are sent out. We shall learn more about this vacuum tube in connection with the discussion of detectors found on page 356.

Whatever the apparatus used in the transmitting station, it must be capable of producing alternating currents of very rapid oscillations, ranging from 1,500,000 to 300,000,000 cycles per second.

One important difference between the waves sent out by the ordinary spark coil and those sent out by the vacuum tube is that the former are damped, while the latter are undamped or continuous. A damped wave dies down quickly, while an undamped wave keeps up its strength through the action of a transmitter which produces a steady flow of waves.

The waves thus sent out weaken with the distance and eventually become so weak that no receiving set so far made is sensitive enough to be affected by them. However, with the improvement of the apparatus the distance that these waves may be picked up is gradually being increased. Reports are seen in the newspapers to the effect that radio sets in this country have picked up waves from stations in Australia, a distance of eight or nine thousand miles. The distance messages may be sent depends on several factors, such as the transmitter, the receiving set, the location of the receiving set with reference to local surroundings, the wave length, and the atmospheric conditions.

One of the most disturbing factors in radio is "static," due to the electrical disturbances in the air. It is more troublesome in summer than in winter, and by day than by night. The radio range by night is many times as great as it is by day, especially on ranges over a hundred miles.

Since the number of messages that may be sent out without interfering with each other is limited, certain regulations have been made regarding the wave lengths that may be used for various purposes. The following table shows the wave length bands adopted in October, 1924:

Kilocycles	Meters	Service
95–120	3,156–2,499	Government C. W. and I. C. W.
120–157	2,499–1,910	Marine
157–165	1,910–1,817	Point to point and marine C. W. and I. C. W.
165–190	1,817–1,578	Point to point and marine C. W. and spark
190–230	1,578–1,304	Government
230–235	1,304–1,276	College experimental C. W. and I. C. W.
235–285	1,276–1,052	Marine phone
285–500	1,052–600	Marine and coastal, including radio compass and radio beacons
500–550	600–545	Aircraft C. W. and I. C. W., phone and fixed life-saving stations phone
550–1,500	545–200	Broadcasting phone
1,500–2,000	200–150	Amateur C. W., I. C. W., and phone
2,000–2,250	150–133	Point to point
2,250–2,500	133–120	Aircraft
2,500–2,750	120–109	Mobile
2,750–2,850	109–105	Relay broadcasting
2,850–3,500	105–85.7	Public service
3,500–4,000	85.7–75	Amateur and army mobile
4,000–64,000	75–4.69	These bands are divided up every few meters between amateur, relay broadcasting, public service, and beam transmission

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The first broadcasting station was established only five years ago, in 1920. Since that time the number of stations has increased rapidly till on September 1, 1924, there were 537. At first phonograph records and piano rolls were used to supply the music, but later these were replaced by musicians in person, and now some of the most talented musicians and speakers in the country are appearing at broadcasting stations. Regular weekly programmes for each day of the week are prepared in advance. These programmes are printed in the daily papers, and some companies send their programmes to persons on their mailing lists.

In the early days of wireless telegraphy many amateurs used transmitting stations. Now, however, before a person can operate a radio transmitter it is necessary to secure a license from the government. A license is required for the transmitting station itself, and an operator's license for the person who is to operate the station. An operator's license is granted only after a rigid examination that indicates that the applicant has mastered the radio code and understands the technicalities of radio transmission. For receiving only, however, no license of any kind is necessary.

THE RECEIVING OUTFIT

As more people are interested in the receiving outfit than in the transmitting outfit, a more complete discussion of the various parts at the receiving end will be given. It will help to make the subject clearer if we state at the outset that the typical receiving set has apparatus for performing five functions: (1) intercepting, (2) tuning, (3) detecting, (4) amplifying, and (5) reproducing.

Intercepting. The radio waves are intercepted and conveyed to the receiving apparatus by means of a system of elevated wires known as the antenna or aërial. For the antenna either copper wire or copper-clad steel wire may be used. This should be about 125 feet long on an average and fastened from twenty to thirty feet above the ground in a horizontal position. It should be insulated at each end. At one end the lead-in wire is connected and run into the house to the receiving set. While the antenna need not be covered with insulation, the lead-in wire should be, and special attention should be paid to the insulation where it passes through the window. (See figure 131.)

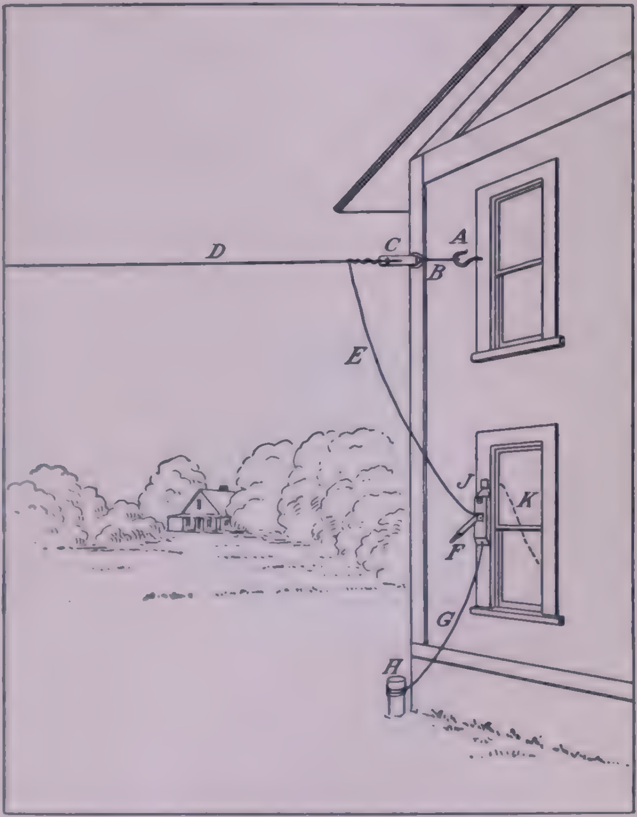


Fig. 131. — Construction of antenna

A, screw eye; B, rope; C, insulator; D, antenna; E, lead-in wire; F, lightning switch; G, ground wire; H, ground pipe; J, insulating tube; K, lead to receiving set.

It is important that a good ground connection should be made. This is best done by connecting with a cold-water pipe.

Protection from lightning should be provided either by means of a lightning switch or a vacuum-gap protective device. In place of a ground connection a counterpoise may be used. This consists of several wires similar to the antenna but stretched much closer to the ground and insulated from it.

Another type of intercepting apparatus is the *loop*, which consists of a number of turns of wire wound around a frame so arranged that it may be turned in any direction. This receives best when its edge points toward the transmitter. A ground connection is not required with the loop. While the loop is quite satisfactory for short distances and well adapted to crowded city conditions, on the whole it is not so effective as the outdoor antenna.

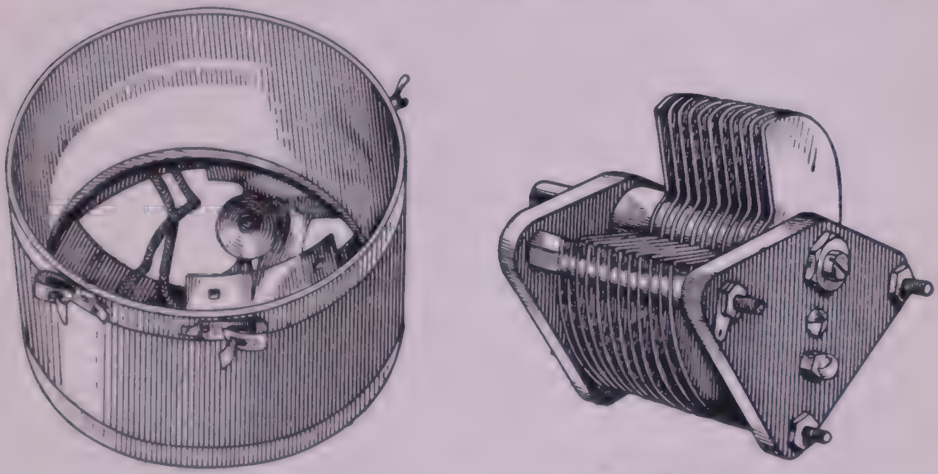
Still another type is the *socket-plug aërial*, which is a device for connecting the set to the electric lighting system and thus using the house wiring as an aërial. Under some conditions this method works satisfactorily, while under other conditions it is a failure.

Tuning. Perhaps the subject of tuning will be made clearer if we start with some illustration in connection with music with which you are familiar. If two strings on a violin are tuned till they give the same note, and if one of these strings is bowed, the other string also will vibrate and give off its note. In radio the principle of tuning is somewhat similar. While we commonly speak of the different wave lengths to which the set is to be tuned, it is well to bear in mind that the vibration varies inversely with the length — that is, as the wave length becomes greater the frequency becomes less. Hence, it is just as appropriate to say that we tune the set for different frequencies as for different wave lengths, and perhaps it may be easier to understand the principle of tuning from this standpoint.

Different broadcasting stations use different wave lengths; and the modern receiving set has a tuning device by means of which the set may be made to respond to various wave lengths. Several kinds of devices have been employed in tuning. One of the first was a coil with a sliding contact by means of which the effective length of the wire in the coil could be varied. At the present time this method is little used.

Varying inductance. The two chief methods for tuning now in use employ devices by means of which inductance and capacity may be varied. As these vary, the wave length to which the set responds varies. We will first explain what is meant by inductance. Every wire that has a current of electricity passing through it has a magnetic field about it. This property that a coil of wire possesses of becoming a magnet is called inductance. If another coil is placed near the first primary coil, magnetism is induced in the second (or secondary) coil. As this inductance changes, the wave length to which a receiving set will respond changes. A strong inductance increases the wave length to which a tuning coil will respond. It has been found by experiment that the mutual inductance between two coils varies according to the distance between them and the angles that they make with one another.

Variocoupler and variometer. (See figure 132.) A variocoupler is a device by means of which two circuits may be more or less interconnected by turning one coil about its axis within the other. The variometer is similar in mechanical construction, the electrical difference being that while in the former the windings of the two coils are separate, in the latter they are connected in series. The variometer serves to vary the inductance of a circuit.



Variocoupler **Variable condenser**

Fig. 132. — Tuning instruments

Varying the capacity. Sets are tuned also by varying their capacity — that is, their power to store up electrical charges. The apparatus that stores these is called a condenser. This must not be confused with the storage battery; the two work on different principles. A condenser consists of two or more conductors, known as plates, separated by a nonconductor, known as the dielectric. In the usual variable condenser the plates are metal sheets and the dielectric is air.

Variable condenser. (See figure 132.) In the variable condenser, part of the plates are movable so that they may be rotated between the fixed plates. By turning the knob the capacity may be changed, being greatest when closed and becoming less as they are separated. Condensers may be used to change the wave length of the receiving circuit to correspond with that of the incoming wave. When a condenser is joined in series with the tuning coil, it decreases the wave length to which the circuit will respond, while a condenser joined in parallel increases the wave length in proportion to the amount of capacity. The variable condenser is capable of very fine adjustments. Hence when you are turning various knobs in tuning a set, you are changing the inductance, the capacity, or both.

Detecting. The current which comes through the tuning controls will not affect the head phones, since it is an alternating current of high frequency. The purpose of the detector is to change this current in such a way that it will affect the phones. Two changes must be brought about: First, the incoming wave must be changed from an alternating to a direct current; and second, the rate of vibration must be greatly reduced. Two types of detectors are used: the crystal and the vacuum tube.

Crystal detectors. Certain crystals, of which galena is most commonly used, have the property of permitting electric currents to pass through in one direction only. Hence when the alternating current from the intercepted radio wave strikes the crystal, only the vibrations in one direction pass through, and as a result a direct current is secured which acts on the head phones. While the crystal detector is cheap and simple, and clear reception is obtained, there are several disadvantages in its use. Its range is limited to relatively short distances, there is a definite limit to the loudness of the signal that can be obtained, and the fine wire, called the "cat-whisker," must be frequently adjusted to a sensitive point.

Vacuum tubes. Another form of detector, known as the vacuum tube, is so much superior to the crystal that its use now is quite general. This wonderful little tube has been called the "Aladdin's lamp" of radio. It has done more than any other single piece of apparatus to make modern radio possible. It serves three distinct uses in radio: In the transmitter it serves as a generator of an alternating current; in the receiving set, it serves two purposes — as a detector and as an amplifier. (See figure 133.)

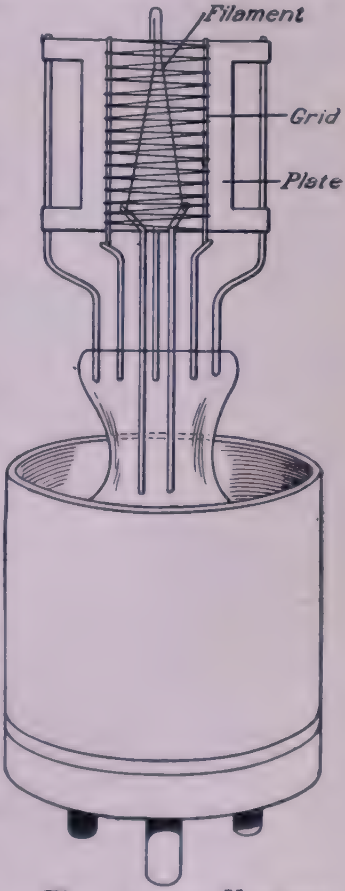


Fig. 133. — Vacuum tube with glass and part of grid removed.

The vacuum tube consists of a glass bulb, looking much like an electric light bulb, from which the air has been removed. Within are found three structures: in the center, the *filament;* surrounding this, a *grid* of fine wire; and outside of this, a metal *plate* in the form of a cylinder. Thus the grid is between the filament and the plate.

Electrons. In order to make clear how this vacuum tube works, it will first be necessary to explain briefly the "electron" theory of matter and electricity, now held by scientists. It was formerly believed that an atom was the smallest particle of matter that could exist; but, in accordance with the electron theory, scientists now believe that the atom is composed of many still smaller units of matter electrically charged, called positive electrons and negative electrons. The atom of each kind of element contains a certain number of electrons. At the center is a nucleus in which positive electricity predominates.

Arranged around this are the negative electrons traveling in their orbits. Under certain conditions some of these negative electrons may leave the atom. For example, when a current of electricity is flowing through a wire, negative electrons are traveling from atom to atom.

Now to return to a further study of the vacuum tube. When the filament is heated to incandescence by means of the battery, millions of negative electrons are given off and pass over to the plate. These electrons form a bridge over which electric currents may pass, but they can pass in only one direction, from the plate to the filament, which is opposite to the direction in which the electrons are moving. Hence the alternating current received through the aërial and tuning coil is changed to a direct current which can then pass on and affect the telephones.

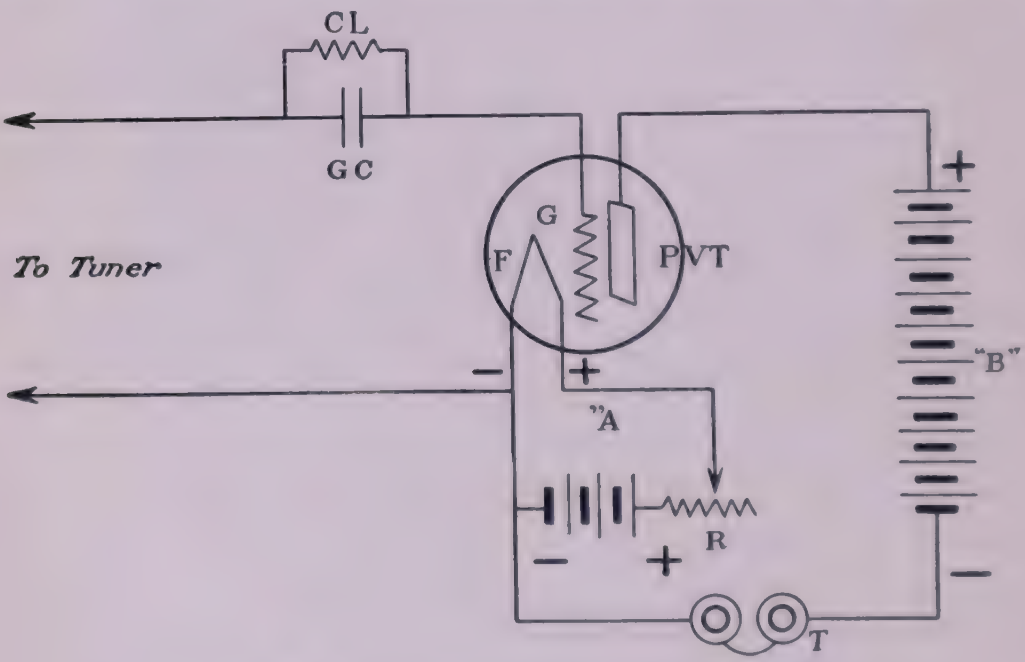
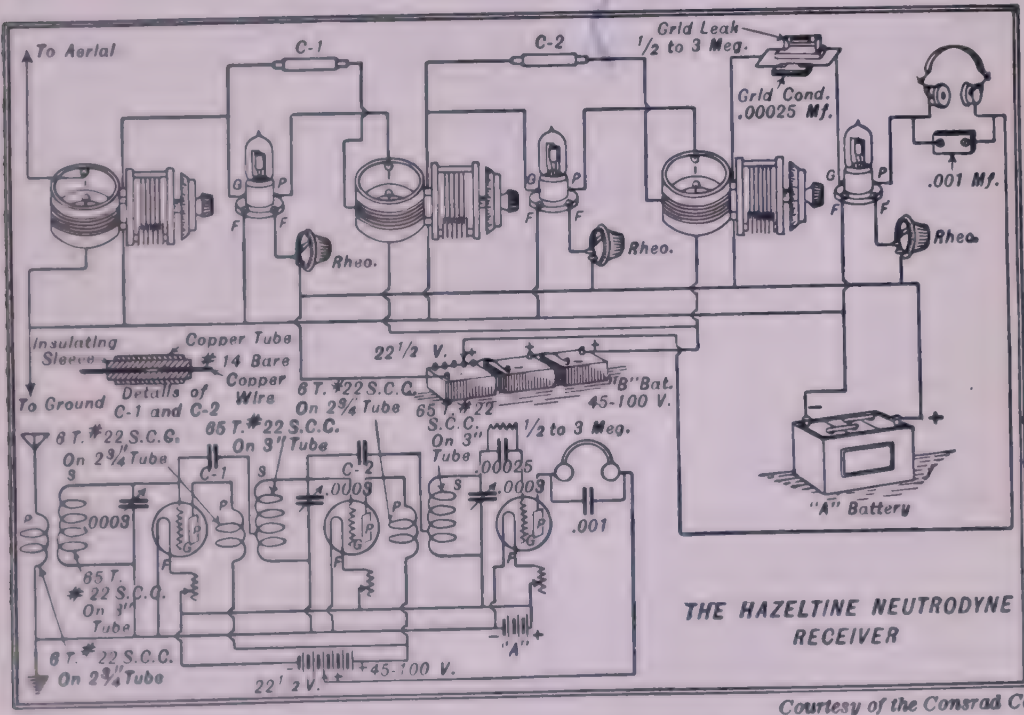


Fig. 134. — Connections of vacuum tube

See Key-Chart to Radio Symbols, pages 360-361.

The purpose of the grid, which lies between the filament and the plate, is to control the number of electrons and hence the amount of current that passes between the plate and the filament and on to the telephone head phones. If the grid is given a positive charge, due to incoming radio signals, a stronger current passes across and on to the head phones. Thus every variation of the radio signals impressed on the grid has a corresponding effect on the electrons' flow, and this in turn affects the current passing to the head phones. The detector tube, it will be noted, is a relay, in fact working on the same broad principle as the telegraph relay.



Courtesy of the Consrad Co.

Fig. 135. — A radio "hookup"

Below, a schematic drawing; above, a perspective drawing.

Two batteries are connected to this tube, an "A" or filament battery and a "B" battery. The use of the "A" battery is to heat the filament, while the use of the "B" battery is to pass the current from the plate to the filament across the electronic

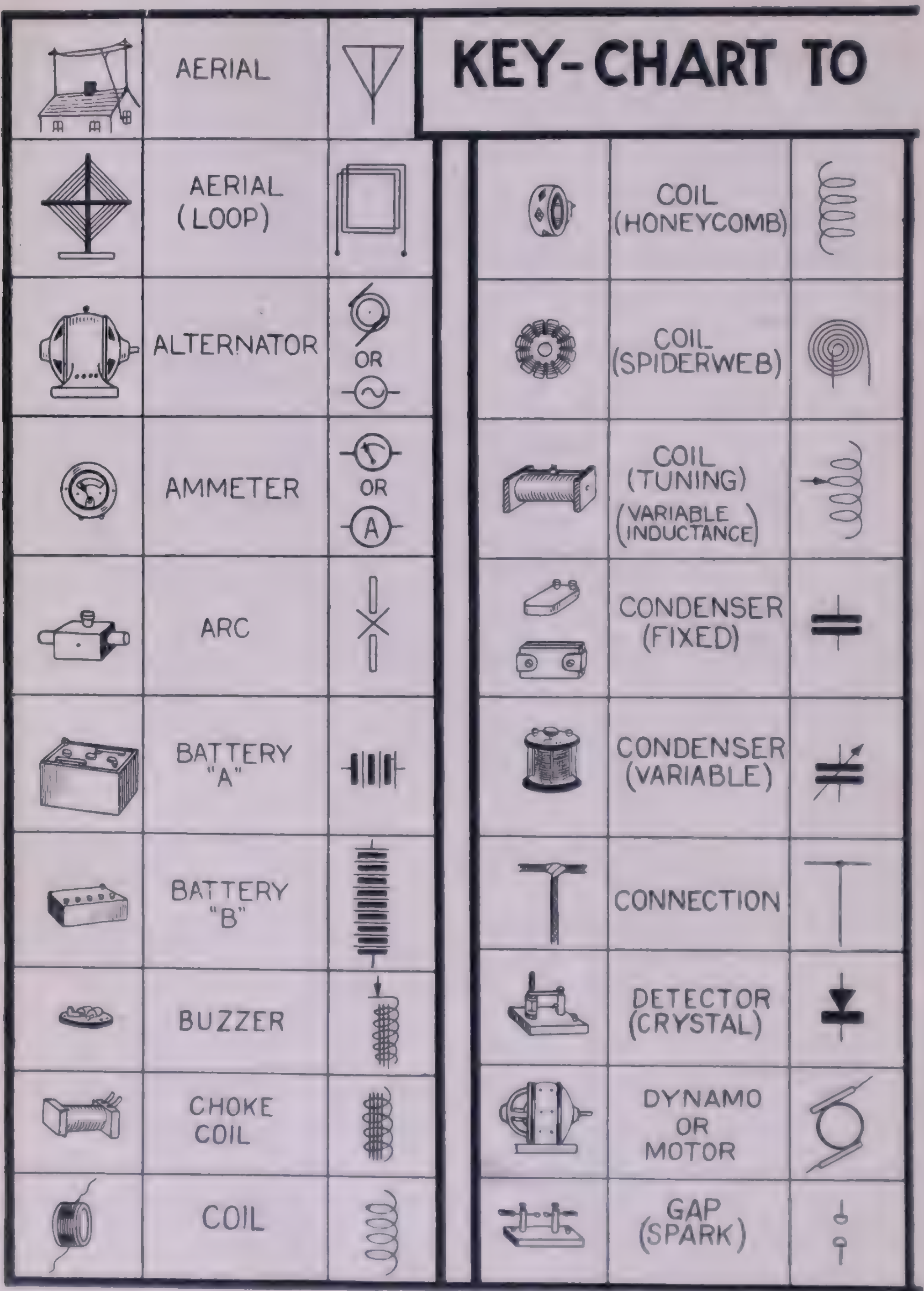
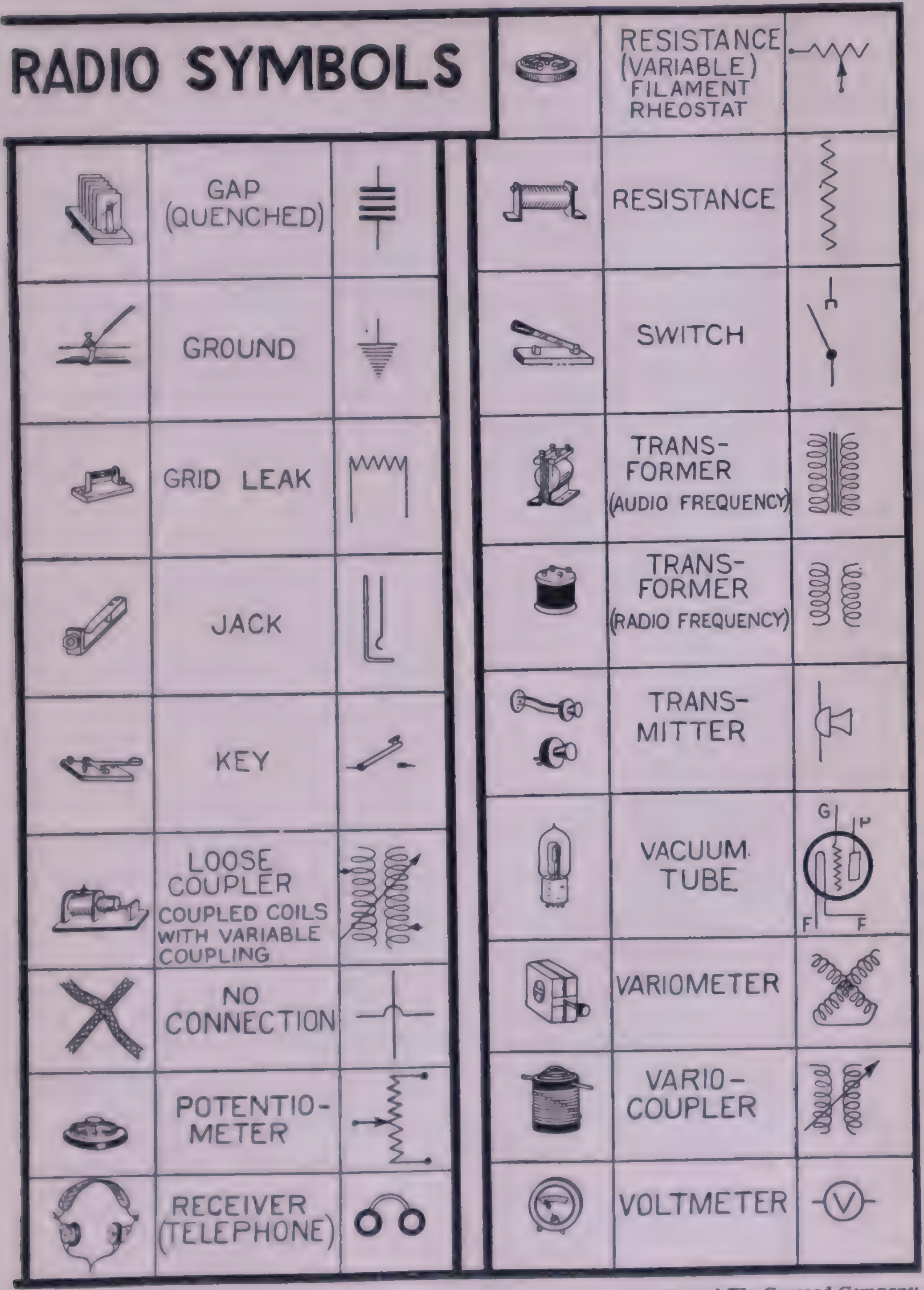


Fig. 136. — Key-chart to



Courtesy of The Conrad Company

radio symbols

bridge. The filament battery is a low voltage battery, while the "B" battery is a high voltage battery of from 16½ to 120 volts. With some tubes dry cells may be used for the "A" battery, while with other tubes a storage battery is used. The connections with the tube are somewhat complicated. It is sufficient to explain that the filament has two terminals and that the grid and the plate have each one terminal. Both terminals of the filament connect with the "A" battery. The plate is connected through the phones with the positive terminal of the "B" battery. The grid terminal is connected with a condenser. Thus it is seen that there are three distinct circuits connected with the vacuum tube: a filament circuit, a plate circuit, and a secondary circuit. (See figure 134.)

Amplifying. An amplifying outfit is not an essential part of a receiving set, but it is commonly used, as it greatly increases the range of the set and the loudness of the sounds. When radio waves have traveled over a long distance, they become weakened; and the purpose of the amplifying outfit is to strengthen them so that they will operate the phones and loud speakers with sufficient volume.

Use is again made of the vacuum tube, which, as we have already seen, is used as a detector. We have learned that the grid may be used to control the current that passes between the plate and the filament. Hence, although the incoming current in the grid may be weak, yet it can be used to control a much *stronger* current, which can be made to act on the telephones.

Types of amplifiers. Two general methods of amplification are used: regeneration and cascade amplification. In the first method of amplification, which takes place after detection, a small quantity of energy in the phone circuit is fed back into the control grid, as a result of which louder sounds are obtained. Various receivers differ in the method of obtaining this *feed back.*

In cascade amplification more than one tube is used, and the plate current of the first tube is caused to act on the grid of a second tube, thus producing a stronger current in the plate current of the second tube. In this system there are two methods of amplification, the audiofrequency and the radiofrequency. The former amplifies the current *after* it passes through the detector, while the latter amplifies it *before* it has gone through the detector. The advantage of the first type is that it gives loud sounds in the phones and the loud speaker. The advantage of the second type is that it increases the sensitiveness of the receiving set so that waves that are so weak as not to affect the detector at all may be strengthened to the point where they will act upon the detector. Both types of amplifiers are often used in the same set, one before the detector and one after. The same batteries that are used for the detecting tube may be used also for the amplifying tube.

Reproducing. *Head phones.* The last step in the cycle is to change the electric waves into sound waves audible to the ear. There are two types of reproducers — the head phone and the loud speaker. The head phone is similar in principle to the receiver described on page 337. However, it is so constructed that it is much more sensitive than the ordinary telephone receiver. It has more windings of a finer wire, the diaphragm is thinner, hence more sensitive, and two receivers are used, so that both ears hear the sounds at the same time.

Loud speakers. The loud speaker requires a much stronger current to operate than a head phone requires; and so the current must be amplified by vacuum tubes, as already explained on page 362.

The various kinds of loud speakers in use may be divided into three classes. (1) The *electromagnetic* type is a modified telephone receiver with a horn attached. This will work on a two-stage audioamplifier. In one make, the telephone receiver may be attached to the tone arm of a phonograph. (2) In the *electro-mechanical* type, the varying pull of the electromagnet is first applied to an armature, which transmits motion to the diaphragm by means of levers, thus supplying mechanical amplification. (3) The *electrodynamic* type is constructed on a somewhat different principle. A small coil of wire is rigidly attached to a diaphragm and suspended in the field of a strong, permanent magnet. The amplified current is brought into the movable coil, and the sounds are given out very much magnified through the vibrations of the diaphragm, to which a horn may be attached. (See figure 137.)

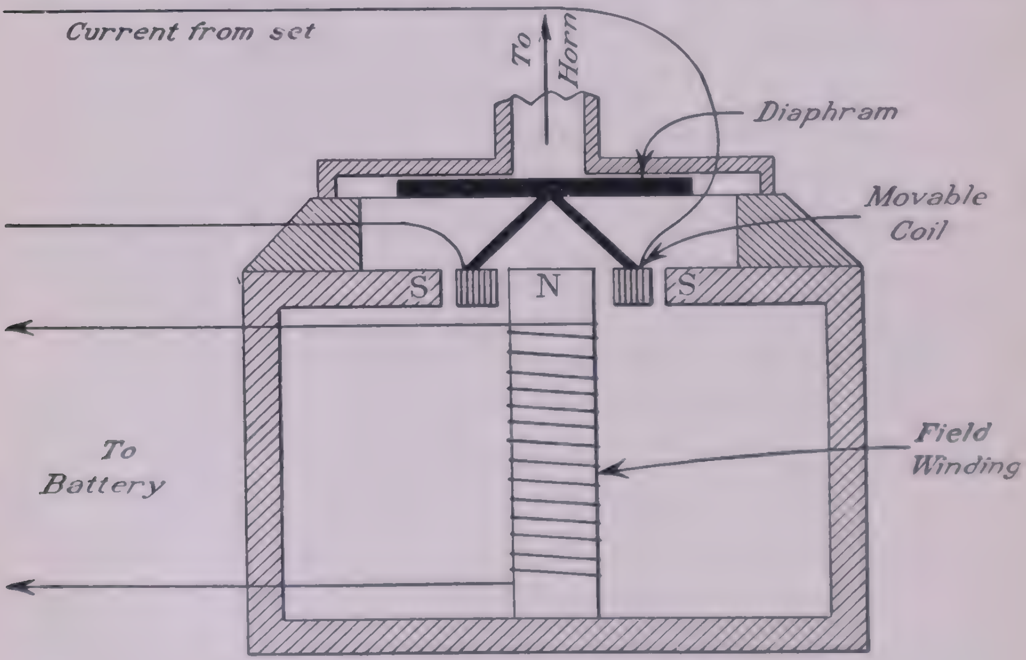


Fig. 137. — Moving coil type of loud speaker

The results obtained with this last type of loud speaker have been truly remarkable, not only in radio but also in connection with public speaking. It is called *magna vox* (great voice). By its use lecturers are able to address huge audiences consisting of a hundred thousand people. A man's voice may be heard distinctly for over a mile, and sounds have been carried for several miles.

OUTLINE SUMMARY

Radio

- I. Uses of radio
    - 1. Uses in connection with receiving sets
    - 2. Radio link
    - 3. Miscellaneous uses
- II. Some principles underlying radio
- III. Broadcasting stations
- IV. The receiving outfit
    - 1. Intercepting
    - 2. Tuning
        - *a*. Varying the inductance
            - (1) Variocoupler and variometer
        - *b*. Varying the capacity
            - (1) Variable condenser
    - 3. Detecting
        - *a*. Crystals
        - *b*. Vacuum tubes
        - *c*. Electrons
    - 4. Amplifying
        - *a*. Types of amplifiers
    - 5. Reproducing
        - *a*. Head phones
        - *b*. Loud speakers

QUESTIONS FOR CLASS DISCUSSION

1. Which do you consider the most important uses of radio?

2. How is it possible for electric waves to travel without wires?

3. What bearing do the electron and the ether theories have on the explanation of radio?

4. What purposes does the vacuum tube serve in radio?

5. What are the principles involved in tuning?

6. What is the value of the amplifying part of a receiving set?

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CHAPTER XXIII

COMMUNICABLE DISEASES

How are communicable diseases spread and how may they be controlled?

BACTERIA AND HEALTH

Bacteria exert a very important influence on health through the part they play in causing a number of common diseases. In some cases the bacterium that causes the disease has been discovered under the microscope, and the cause of the disease is thus definitely known. It has been discovered for diphtheria, tuberculosis, typhoid fever, pneumonia, cholera, lockjaw, whooping cough, and blood poisoning. There are other diseases that are so similar to bacterial diseases in their general behavior that they are generally believed to be caused by bacteria or other microbes, although the bacterium has not been discovered. Of this nature are scarlet fever, measles, mumps, and smallpox.

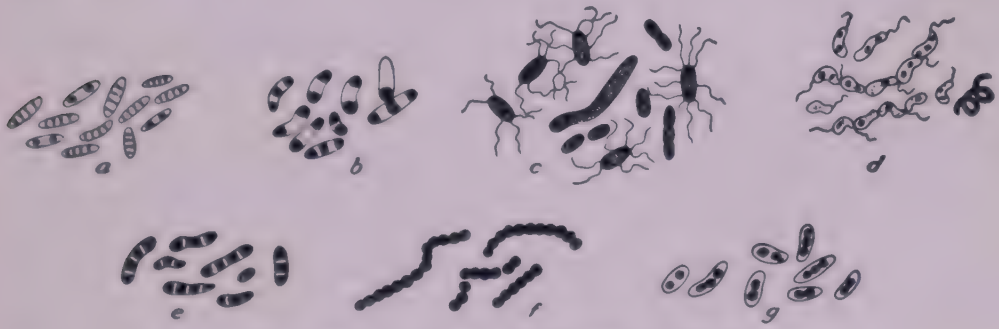


Fig. 138. — Types of disease bacteria

***a*, tuberculosis; *b*, diphtheria; *c*, typhoid fever; *d*, vibrio of cholera; *e*, anthrax; *f*, erysipelas; *g*, pneumonia.**

There is a great difference in people as to the degree to which they may be affected by these bacteria. Several people exposed to the same disease may all take the bacteria into their systems, and yet while one person becomes sick, others may be affected very slightly or not at all. One person may have disease germs in his system and not be affected by them, while another person may receive these germs from the first person and come down with the disease.

CHARACTERISTICS OF BACTERIA

In order to understand how bacteria cause disease and what may be done to control them, we need first to learn something about their general activities.

Size. Bacteria are the smallest living things that have been discovered with the microscope. They vary in size from a ten-thousandth to a hundred-thousandth of an inch in diameter. There are probably others so much smaller that they cannot be seen even with the aid of a microscope. It would take about fifteen hundred bacteria of average size placed end to end to reach across the head of a common pin. It has been estimated that a pint can would hold over two hundred billion bacteria.

But although they are so extremely small, yet these little plants play a very important part in man's life on account of their frequent occurrence and their power of rapid reproduction. While we cannot see bacteria without the aid of the microscope, the effect of their action in masses is evident all around us, as in the souring of milk, the spoiling of food, and the decay of refuse and other organic matter.

Multiplication. The great abundance of bacteria depends upon the remarkable rapidity with which they grow and form new bacteria. Their method of multiplication is a process called division. A bacterium divides into two similar parts, each part growing meanwhile till it is as large as the first bacterium. In a short time, sometimes in twenty minutes, these two divide to make four; in another twenty minutes, these four divide to make eight, and so on, each division doubling the number of bacteria. At this rate, the descendants of a single bacterium would amount in ten hours to about a billion. Bacteria do not continue to grow at this rate indefinitely, because the limit of their multiplication is soon reached through lack of food and through other conditions unfavorable to growth. It is this tremendous power of multiplication that makes them such a factor in man's life.

Occurrence and food. Bacteria are found in a great variety of places: in the soil, in the air, in water, in food, and in the human body. While some kinds are injurious to man, the great majority are either beneficial or harmless. While fifteen hundred kinds of bacteria are known to science, only about fifty to seventy-five produce disease. Although these little organisms are plants, they contain no chlorophyll and hence cannot make their own food. Some bacteria live on the dead bodies and others on the living bodies of plants and animals.

DEMONSTRATION 48

Purpose. To see under what conditions air contains the fewest bacteria.

Materials. Sterilized test tubes containing culture medium; Petri dishes.

Directions. 1. The culture medium can be bought all prepared from dealers directly or through drug stores. It can also be made as explained in Conn's *Bacteria, Yeasts, and Molds in the Home.* It will be convenient to melt the culture and fill a number of sterilized test tubes about half full. Plug each tube with cotton batting.

2. Melt as many tubes of the medium as there are samples of air to be tested. Pour each into a sterilized Petri dish and cover at once. Allow to stand till the gelatin hardens.

3. Some of the various localities and times for testing the air are as follows: in the schoolroom before school and after school; in the hall while classes are passing and just after sweeping; outdoors on a windy day and on a still day; on a street that is much traveled; and on a street that is little traveled.

4. In each of the cases to be tried, remove the cover from the dish, keeping it off for three minutes, and then replace.

5. Allow the dishes to stand for several days; note the appearance of colonies. If possible, count them. If they are too numerous for this, determine the relative number of bacteria found in the various localities. Or the experiment may be tried again with a shorter exposure, so as to reduce the number of colonies.

Conditions of growth. After a suitable food supply, the most important conditions affecting the growth of bacteria are temperature and moisture. For the majority of bacteria the most favorable temperature is between sixty and one hundred degrees. The effect of lowering the temperature is to lessen their activity, and they become inactive near the freezing point. At this point many kinds are killed, although some can withstand freezing for several weeks or months. Such are the bacteria that cause typhoid fever: When ice melts in which these have been frozen for two months or longer, some of them may renew their activities. All bacteria, however, are killed by boiling; and, if the heating is continued for an hour, they may be destroyed at a temperature of 160 degrees.

There is one form in which bacteria exist, known as spores, in which they are not destroyed at once by heating them to the boiling point. Under certain conditions some bacteria stop their activities and form themselves into a globular mass surrounded by a thick membrane. These spores are able to withstand adverse conditions, such as excessive drying and heat, which would kill bacteria in their ordinary forms. However, while spores are not destroyed by boiling a short time, if the boiling is continued for several hours the spores will be killed.

Two other conditions favorable to the growth of bacteria are dampness and darkness. Bacteria cannot withstand drying and the action of direct sunlight; hence the need of having our houses well lighted and our windows free from obstructions.

RELATION OF BACTERIA TO DISEASE

The bacteria in their action within the body produce poisons, called toxins, which are absorbed into the blood and produce the effects characteristic of the several bacterial diseases. All these diseases may be transmitted from one person to another; some, however, are more highly contagious than others. It is important that everybody should know something about these diseases — how they are caused, how they may be carried, and how they may be avoided. Then everyone will understand how to protect himself and his home and how to coöperate intelligently with the board of health and other organizations whose duty it is to look after the public welfare.

In considering the part that bacteria play in disease, we need to understand three things: first, how the bacteria leave the body of a sick person; second, how they are distributed from place to place; and third, how they enter the body of a well person.

How bacteria leave the body. The chief ways in which disease bacteria leave the body are the following: in the sputum, in the feces, in the urine, and in eruptions of the skin. Sometimes a patient who has recovered entirely from a contagious disease may continue to give off disease germs from his body for several years, thus proving a source of danger to the community. Such persons are called "chronic carriers" of the organisms present.

How bacteria are distributed. The chief means by which these bacteria are distributed are contact, water, milk, food, and flies. By contact is meant the transfer of fresh germs through short distances from patients or carriers to people near. This may be through mouth spray, clothing, or eating-utensils, or by direct contact, as in kissing. One of the commonest ways of transfer by contact is by the hands. These are carried to the mouth many times a day; and if they have come in contact with moist germs, these germs find easy access to the mouth. The part played by milk and water in spreading disease germs is explained in the following chapter.

Formerly it was believed that the germs were carried by dust, books, letters, and other articles that had been touched by the patient; but today medicine is emphasizing especially the danger of direct contact with the patient through the hands and the sputum given off as a fine spray in coughing and in conversation. Experiments have shown that in ordinary conversation this spray may be carried three or four feet, and in coughing, ten feet. This spray is believed to be one of the common means by which colds are carried, as well as the other diseases in which the infecting organisms are present in the lungs, nose, throat, and mouth.

Since drying and sunlight soon kill bacteria, it is not believed that dust is a very common means of carrying disease germs.

One way in which moist sputum may be carried is by shoes and rubbers. These carry the germs directly to the carpets and rugs inside the house and may prove especially dangerous to babes playing on the floor.

The following table shows the most common routes of infection of a few diseases:

DISEASES	CHIEF ROUTES OF INFECTION
Typhoid fever (and other intestinal infections)	Contact; milk; flies; food; water
Tuberculosis (human)	Contact; milk; flies
Diphtheria, scarlet fever	Contact
Trachoma, cerebrospinal meningitis, leprosy	Contact

From this it will be seen that water and food carry only the intestinal infectious diseases and that flies as carriers are limited to this group chiefly, as the amount of tuberculosis carried by flies is small. Milk may carry the first three groups, while contact alone may carry them all.

How bacteria enter the body. The chief ways by which bacteria may enter the body are through the mouth in food or drink, through the nostrils and mouth in breathing, and through wounds in the skin. The first two are the most common ways.

The various ways in which these microbes may leave the body of the patient, how they may enter the body of another person, and how they may be carried from one person to another are shown in the following table:

TABLE OF SOME COMMON DISEASES

DISEASE	HOW ORGANISMS LEAVE THE BODY	HOW ORGANISMS ARE CARRIED	HOW ORGANISMS ENTER THE BODY
Diphtheria .	By coughing; in sputum	Contact; milk	By breathing; by mouth through hands, food, or drink
Tuberculosis .	In sputum; by coughing	Contact; milk; meat; flies	By breathing; by mouth through hands, food, or drink; through wound in skin
Typhoid fever	In feces and urine	Contact; milk; food; flies; ice	By mouth through milk, food, or, water
Pneumonia. .	Coughing	Dust particles in air; contact	By breathing
Lockjaw . .		Soil and dust particles in air	Wounds in skin
Smallpox . .	Probably through nose and throat secretions	Contact	By breathing; by mouth through hands and possibly food or drink
Scarlet fever .	Sputum; discharging ears; nose and throat discharges	Contact; milk	By breathing; by mouth through hands, food, or drink
Measles . .	Probably through nose and throat secretions	Contact	By breathing; by mouth through hands and possibly through food or drink

TABLE OF SOME COMMON DISEASES—*Continued*

DISEASE	HOW ORGANISMS LEAVE THE BODY	HOW ORGANISMS ARE CARRIED	HOW ORGANISMS ENTER THE BODY
Whooping cough	Coughing	Contact: milk	By breathing; by mouth through hands, food, or drink
Hydrophobia		Dogs	By wound
Infantile paralysis .	Throat discharges; sputum	Contact	Probably same as whooping cough
Trichinosis .		Pork	Eating pork
Malaria . .	Blood	Mosquito	Injected by mosquito
Bubonic plague	Blood	Fleas on rats	Flea bites a person
Influenza and grippe	Coughing	Contact; air	By breathing; by mouth through hands, food, or drink

HOW TO CONTROL COMMUNICABLE DISEASES

The facts that we have learned in this chapter show that in order to control these diseases, the first step is to take such care of the sick persons that they cannot give the diseases to others. In some cases these patients must be kept by themselves, and others who may have been exposed must be quarantined, in order to protect the health of other people. But these precautions alone are not sufficient, because people may have mild forms of diseases without being seriously sick and may yet give off disease germs. Further, as already explained, some people may continue to give off germs for some time after they have recovered from the diseases. Therefore it is necessary to guard the public routes of infection by which the germs may be carried — namely, water, milk, and food.

A few facts about the methods of controlling some of the more common and dangerous diseases will now be given, so that each one may do his part toward helping to lessen the harm done by these diseases.

Smallpox and vaccination. It is a well-known fact that after a person has recovered from certain diseases, he is protected to some extent from contracting those same diseases again. In some cases this protection may be complete and may last for years; in other cases the protection may last for a short time only. The principle involved is the one applied in vaccination as a protection against smallpox. This practice was devised over a hundred years ago by an Englishman named Dr. Jenner. Cows are subject to a mild disease known as cowpox, which is very similar to smallpox. In vaccination there is introduced into a person's system some vaccine which contains the active principle of cowpox. This is obtained from calves raised especially for this purpose. If vaccination "takes," it causes a very mild form of cowpox; but as a result, the person is protected from the dangerous disease of smallpox.

When the virus that causes cowpox enters the blood, the blood makes a substance, called "antibody," which offsets the effect of the poison, and the person recovers. This antibody, thus made, remains in the system and is effective also in preventing injurious effects from any smallpox microbes that may enter the body. The time that this immunity lasts varies with different people, the average time being about seven years, although a single vaccination affords some slight degree of immunity for a lifetime. In order to be on the safe side, a person should be revaccinated at frequent intervals and whenever the disease is present in a community.

Effect of vaccination on the death rate. Serious epidemics of smallpox are so rare in this country today that people are apt to become careless about the matter of vaccination, overlooking the fact that it is vaccination which has made this freedom from smallpox epidemics possible. Statistics furnish conclusive evidence of the great blessing to mankind that vaccination has proved in saving hundreds of thousands of lives.

Before the discovery of vaccination, smallpox was one of the most common diseases, even more common than measles today.

The great majority of people at some time had the disease. In the city of Boston in 1721, over half the people had the disease,

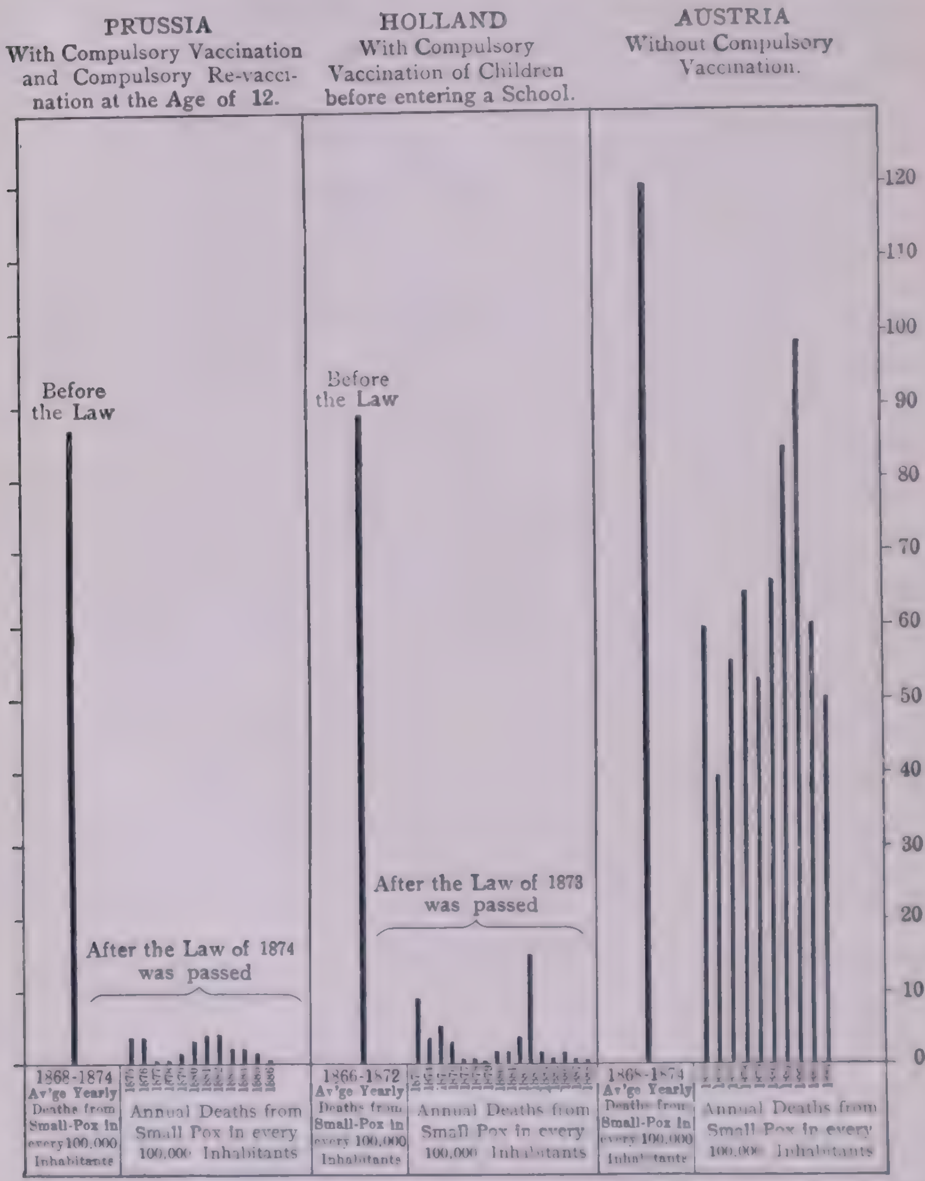


Fig. 139. — Effect of compulsory vaccination on the death rate from smallpox

and one thirteenth of the population died of it. Nine years later, there was another epidemic which was almost as severe.

During the centuries past, smallpox has been one of the greatest scourges throughout the world, sweeping off people by the thousands. It has been estimated that sixty million people died of smallpox in Europe in the eighteenth century.

Today an epidemic of smallpox is of rare occurrence in those countries where vaccination is commonly practiced, and the number of deaths from this disease is very small. Records that have been kept of the deaths from smallpox show that among people who have not been vaccinated the percentage of those who die averages ten times as great as among those who have been vaccinated.

In five European countries in which vaccination is compulsory, the average number of deaths from smallpox per million of population is five; while in six European countries that do not have compulsory vaccination, the average number is four hundred, or eighty times as high.

When vaccination has been made compulsory in a country, the effect on the death rate has been very marked at once. In 1874 Germany passed a compulsory vaccination law. As a result, the average number of deaths from smallpox for the ten years following was only two per hundred thousand population, while for the ten preceding years it had been seventy-one. This meant a yearly saving of about twenty-five thousand lives, or of about 250,000 for those ten years alone. During that same period of ten years the death rate in the neighboring country of Austria, where vaccination was not compulsory, was sixty-two per hundred thousand of population, as compared with two in Germany where it was compulsory. In Sweden, the rate of cases of smallpox per million inhabitants was two thousand before vaccination; it fell to five hundred when vaccination was made optional, and to five when it was made compulsory.

One sometimes hears objections raised against vaccination, because occasionally it has been followed by serious results.

However, in most of the cases that have been carefully investigated, it was found that the ill effects were not due directly to the vaccine, but to bacteria which had entered the wound as a result of someone's carelessness in the preparation of the vaccine or in the care of the wound, through scratching with dirty fingernails, or from dirty clothing. However, while formerly smallpox vaccine exceptionally contained bacteria which gave rise to serious results, the methods now used in the manufacture of vaccine, together with the preliminary biological tests made of the product before it is placed upon the market, insure its safety. In other words, the dangers of infection from the vaccine itself are a matter of the past.

Notwithstanding the arguments of those opposed to vaccination, the evidence is indisputable that vaccination has been the chief means of controlling smallpox and saving thousands of lives, and it still remains the most effective means of preventing epidemics of smallpox.

Diphtheria. *Antitoxin treatment.* One of the discoveries of recent years is the antitoxin treatment for the cure and prevention of diphtheria. This remedy was announced in 1890 by a German named Dr. von Behring.

Horses are carefully kept for the special purpose of making antitoxin to be used with human beings. Strong, healthy horses are kept in clean stables and carefully looked after. They are first injected with the toxin which causes diphtheria, but not with the bacteria; as a result, they make in their bodies antitoxin, which offsets the effects of the toxin. Blood is drawn from the necks of the horses in an almost painless way; and in this blood is found the antitoxin.

The serum of this blood is injected into the blood of a person suffering from diphtheria, and the antitoxin offsets the effects of the toxin produced by the diphtheria germ.

It is very important that the antitoxin should be administered in the early stage of the disease. If injected at the onset of the disease, the recoveries are nearly 100 per cent. The later it is given, the less effective it proves, as shown by the following table:

TIME USED	RECOVERIES PER CENT
Onset of disease	100.
First day	97.8
Second day	92.4
Third day	82.9
Fourth day	76.2
Fifth day	66.1
Sixth day	65.9
After sixth day	61.2

Not only is this treatment an almost sure cure for diphtheria if it is taken in the early stages, but it is also effective as a preventive when given to members of the family who have been exposed. This immunity, however, does not last long — usually not more than four weeks.

The chief difference between the principle involved in vaccination for smallpox and that involved in the use of antitoxin for diphtheria is that in the former case the body makes its own antibody, while in the latter case this antibody is made in the body of the horse and then injected into the human system.

Statistics everywhere show a remarkable lowering of death rates where this treatment is applied. Only 10 per cent of those who have the disease now die, where formerly 50 per cent was the rule. As a result of this treatment, diphtheria has passed from being one of the most dreaded diseases to being one that is seldom fatal if taken in time. A wider application of this treatment would lower the death rate still further.

The following table shows how the use of antitoxin has reduced the death rate:

DEATH RATE FROM DIPHTHERIA AND CROUP PER 10,000 POPULATION

	BEFORE ANTITOXIN	AFTER ANTITOXIN											
CITY	1887–1893	1896–1899	1900–1905	1906–1910	1911	1912	1913	1914	1915	1916	1917	1918	1919
Denver	12.9	1.7	2.9	2.3	1.6	0.5	0.8	0.4	0.3	0.1	0.8	1.1	1.0
New York	14.5	6.3	5.1	3.8	2.6	2.2	2.6	2.9	2.4	1.9	2.1	2.3	2.2
Philadelphia	11.9	9.6	4.0	3.3	3.1	2.3	2.1	1.9	1.8	2.2	2.5	2.1	2.4
Chicago	13.1	5.0	2.8	2.3	3.8	4.1	4.1	3.2	2.7	3.1	4.7	2.7	2.2

Toxin-antitoxin treatment. A still more recent development is the use of a mixture of diphtheria toxin and antitoxin. The great advantage of this method over the antitoxin treatment is that the immunity lasts for years, whereas in the other case it lasts only for weeks. A disadvantage is that it takes much longer (from three to six months) to become effective. Hence the toxin-antitoxin should be used before exposure occurs. If used at the time of exposure, protection is not established soon enough to protect.

Since diphtheria is largely a child's disease, from three to ten years being the most susceptible age period, the treatment to be most effective should be given to young babes. Most adults are immune to diphtheria.

The Schick test. Some people are immune to diphtheria and others are not. By means of the Schick test it is possible to tell which persons are immune and which are not. The toxin-antitoxin treatment should then be given to those who are not immune.

Diphtheria could be practically eliminated by the universal application of known methods of dealing with the disease — namely, the Schick test, the toxin-antitoxin treatment, and the antitoxin treatment.

Typhoid fever. *How spread*. There are two diseases of common occurrence which are the cause of so many preventable deaths that special mention should be made of them. They are typhoid fever and tuberculosis. These are due largely to people's carelessness and ignorance, and hence are preventable diseases.

Water. Typhoid fever germs are often spread through water. These bacteria live in the intestines of the patient and pass out in both the feces and the urine. They may pass directly with the sewage into some stream, or they may be deposited on the soil, from which they may be washed into wells through surface pollution.

In cities that have a system of sewers, it sometimes happens that the sewers empty into a stream from which a city lower down takes its drinking water. When typhoid fever breaks out in the first city, the bacteria are carried to the second city, where another outbreak occurs. It is thus seen that the prevention of water-borne typhoid fever depends largely on three precautions: the proper disposal of the sewage, the protection of drinking water, and the purification of drinking water. Some facts about the purification of water are given in the next chapter.

Boiling water. If the water supply is suspected of being contaminated with typhoid germs, the surest protection is to boil for a half hour all water to be used for drinking purposes. The great majority of the common small filters, which contain sand and charcoal and are attached to the faucet, are worse than useless. They do not remove the bacteria from the water, and the dirt that collects becomes a breeding place for bacteria.

DEMONSTRATION 49

Purpose. To see if ice contains bacteria.

Materials. See Demonstration 48 and read "1" under "Directions."

Directions. Melt a piece of ice in a sterilized beaker. Take one cubic centimeter of the water and add it to a test tube containing melted culture medium. Shake and pour into a sterilized Petri dish. Cover, allow to stand a few days, and see if any colonies appear.

Recovered patients a source of infection. Another consideration that emphasizes the need of continual care in measures directed against typhoid fever is the fact that even after a patient has recovered from the disease he may continue to carry typhoid germs in his body for several years. These are given off in the wastes of the body, which may thus be a means of spreading the germs. Thus such a person may be as dangerous to the health of a community as are typhoid patients. It is estimated that from 3 to 5 per cent of all people who have had typhoid become carriers of the disease, sometimes for years or even for a lifetime.

Food. The germs of typhoid fever may sometimes be carried in various articles of food, as uncooked fruits and vegetables and raw oysters. Epidemics of typhoid have occurred from eating uncooked oysters, which, it was later found, had fattened in a bay into which had emptied the sewage from a house containing a typhoid patient. It is a wise precaution in the use of fruits and vegetables to wash them thoroughly before eating, and in the case of oysters to cook them.

Vaccination for typhoid fever. Modern science has found a means of preventing typhoid fever through vaccination. In times of war, typhoid has always been the scourge of armies. In the Spanish-American War, more soldiers died from this disease than were killed in battle. This idea of vaccination originated with Professor Wright in England and was first tried on a large scale in the British army. It has now come to be commonly practiced throughout the world and has proved so successful that typhoid fever is no longer a menace to armies. Wherever vaccination has been introduced, the death rate from typhoid fever has decreased to a remarkable degree. In the United States army, for the first three years after vaccination was made compulsory the number of cases was reduced to one twentieth and the number of deaths to one fifteenth of what they had been for the three years before vaccination.

The closed window **Overwork**

Crowded rooms **Mouth breathing**

Fig. 140. — Allies of consumption

The campaign against typhoid fever has shown results in a lowered death rate, which has fallen from 23.5 in 1910 to 7.5 in 1922.

Tuberculosis. Another disease that should be especially mentioned is tuberculosis of the lungs, or consumption, as it is called. One twelfth of all deaths are due to this disease alone, the annual number of deaths from consumption in the United States being about a hundred thousand. The deaths from this one disease equal the total number caused by the following fourteen diseases combined: smallpox, typhoid fever, scarlet fever, bronchitis, diphtheria, measles, diabetes, appendicitis, meningitis, rheumatism, malaria, whooping cough, croup, and erysipelas. The number of people in the United States suffering from consumption is about one million.

These figures have been given so as to emphasize the next statement, that most of this terrible loss of life is *unnecessary*, because tuberculosis is a curable and preventable disease. It is the purpose of the next few pages to give some of the information that one needs in order to enable him to act his part as an intelligent citizen in the widespread movement to stamp out this disease.

By sputum

By two people taking bites from the same apple

Fig. 141. — How the germs of consumption are carried from the sick to the well

It is encouraging to know at the outset that the death rate from tuberculosis has been steadily declining. It has fallen from 160.3 in 1910 to 97 in 1922.

How bacteria leave and enter the body. Tuberculosis of the lungs is caused by bacteria that live in the lungs and cause little rounded bodies known as tubercles. These break down and open into the smaller air passages or bronchi, and thus the bacteria reach the sputum. While the chief way in which they are thrown out is in the act of expectoration, they may also be thrown off in the mouth spray in the acts of coughing and sneezing. The bacteria may find entrance into another body in three ways: (1) by being breathed in through the mouth or nostrils, (2) by being taken in food or drink, and (3) by entering wounds. The first two ways are the most common.

Bacteria in foods. It is known that cattle are subject to tuberculosis, and it has now been definitely proved that the bacteria of tuberculosis may be taken into the human system through the meat and milk of diseased cows.

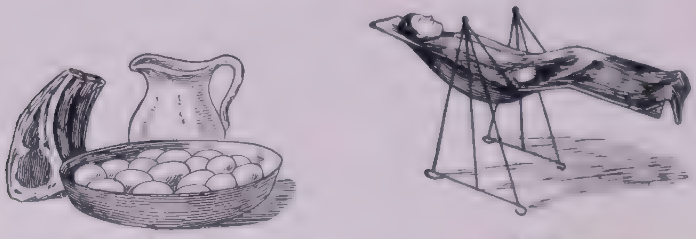
It has been found that young children are specially susceptible to the germs in milk from tuberculous cows. These bacteria may be found not only in the milk itself but also in the products obtained from it, as cream, butter, and cheese. Investigations made in Europe indicate that the percentage of butter containing the bacteria is slightly larger than the percentage of milk.

Public drinking cups. The public drinking cup is another means of spreading the disease. Tuberculous people use these cups, and in the saliva left on the edge are thousands of the bacteria, which are taken into the mouth of the next person using the cup. The use of drinking fountains is removing the menace of the drinking cup.

Cure of tuberculosis. The cure of tuberculosis consists in the employment of three things: fresh air (night and day), plenty of nourishing food, and rest. All medicines advertised as cures for this disease are useless; some of them may be actually harmful. It is not usually necessary for one to go to any particular climate, the essential thing being a location where a constant supply of pure, fresh air may be obtained.

Window tent. The window tent is an excellent device for use in winter to secure fresh air without cooling the room in which the patient is sleeping. This is simply a frame covered with canvas, resting on the head of the bed and so fastened to the window that little air can enter the room. In the lower part is an opening through which the head may pass into the inclosure which receives the air through the window. By this means the sleeper obtains a constant supply of fresh air for breathing, while his body is not cooled thereby. A serviceable homemade tent may be constructed out of stiff wire and canvas. This need be used only in the colder months, as at other times the windows can be kept wide open without any discomfort.

The doctor Sunlight Outdoor air



Good food Rest

Fig. 142. — Helps in the cure of consumption

Prevention of tuberculosis. Care of sputum. The prevention of tuberculosis must look in the first place to the proper supervision of those who already have the disease. As the sputum of these patients is the chief means by which the disease is spread, the first care must be the proper disposal of this sputum. This should be deposited either in paper napkins, which should be burned, or else in covered metal cups which contain some chemical to kill bacteria.

The use of common dishes, drinking cups, and towels should be avoided. One should not stand near and directly in front of a patient while he is talking, since bacteria are given off in the mouth spray.

A tuberculous person should never expectorate in public places, where the sputum may become a source of danger to the public. As people often have the disease in the early stages and do not know it, the general rule should be followed by everyone not to expectorate in public places. The signs so frequently seen prohibiting expectoration are designed to lessen the possibilities of the transmission of tuberculosis.

Protection of food. The bacteria in meat may be killed by a thorough cooking. Those in milk may be destroyed by pasteurizing as described on page 410. The presence of tuberculosis in cattle may be detected by means of a special test. There are laws regulating to some extent the kind of cattle that may be kept by dairymen or sold as meat; and where these laws are rigidly enforced, the public is partially protected against the danger from tuberculous cattle.

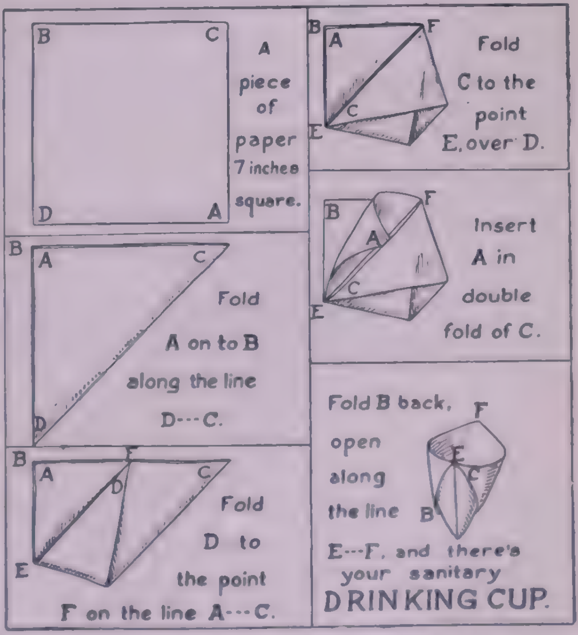

B
C
D
A
A piece of paper 7 inches square.
B
A
F
C
E
Fold C to the point E, over D.
B
A
C
D
Fold A on to B along the line D---C.
B
A
F
C
E
Insert A in double fold of C.
B
A
F
D
C
E
Fold D to the point F on the line A---C.
Fold B back, open along the line E---F, and there's your sanitary DRINKING CUP.
F
E
C
B

Fig. 143. — **How to make a drinking cup**

Anti-tuberculosis movement. In recent years people have become so awakened to the fact that tuberculosis is one of our most fatal diseases, and yet that it is curable and preventable, that organizations have been formed throughout the world for the purpose of combating this disease. In this country there are many city committees and state organizations devoted to this purpose; and a few years ago there was formed the American National Association for the Study and Prevention of Tuberculosis. And finally the various nations have organized an International Tuberculosis Congress. These organizations are doing much in educating the people by means of exhibitions and the distribution of printed matter.

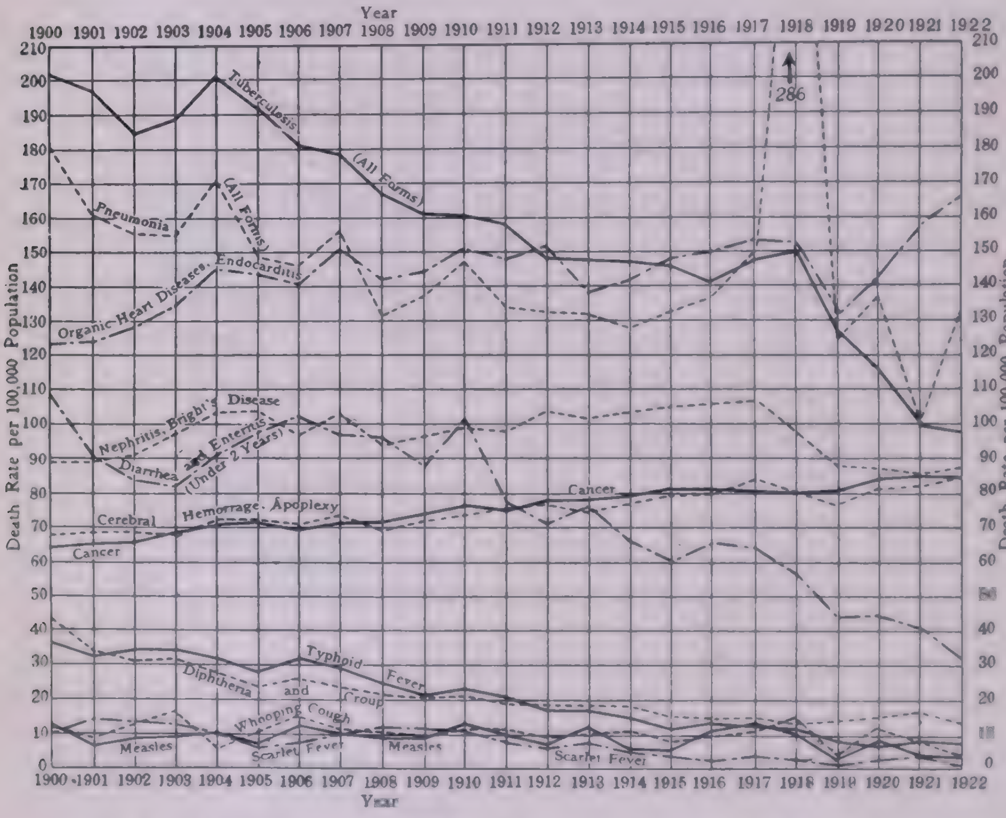


Fig. 144. — Death rates from important causes of death

Sanatoriums. Many states and cities have instituted sanatoriums where treatment may be given to consumptives. Some large organizations and private companies have planned sanatoriums for the benefit of their members and employees. Frequently neighboring counties unite in building a sanatorium.

LABORATORY EXERCISE 12

Purpose. To compare the death rates for various diseases.

Materials. Figures 139 and 144.

Directions. 1. In figure 144 notice which three diseases cause the greatest number of deaths and which five cause the least.

2. Make a table like the following in your notebook:

DISEASE	DEATH RATE	NUMBER WHO DIE	PER CENT OF DECREASE SINCE 1900	PER CENT OF INCREASE SINCE 1900

Fill in the figures for the first three columns for each disease for 1922, counting the population of the United States as 110,000,000. Put first the disease with the highest death rate, and arrange the rest in order.

3. Beginning with diseases having the lowest death rates, add together the number of people killed till you get a total equal to the number killed by tuberculosis alone. How many and what diseases does it take to do this?

4. For which diseases has the death rate been decreasing? For which increasing? Compare 1922 with 1900 and work out for each disease the per cent of increase or decrease. Put the figures in the fourth and fifth columns of the table above.

5. Study figure 139 to notice the effect of vaccination on the death rate from smallpox. What does the figure show (*a*) for Prussia? (*b*) For Holland? (*c*) For Austria?

6. In Prussia what was the average annual death rate for the six years before vaccination was made compulsory? What was it for the six years after? The population of Prussia for 1880 was 27,000,000. Compute the number of lives saved in Prussia through vaccination from the years 1875 to 1886, taking the above figure as the average population for these years.

7. Do the same for Holland, whose population in 1880 was nearly 4,000,000.

8. Estimate the number of lives that might have been saved in Austria in the years from 1875 to 1884 if vaccination had been made compulsory

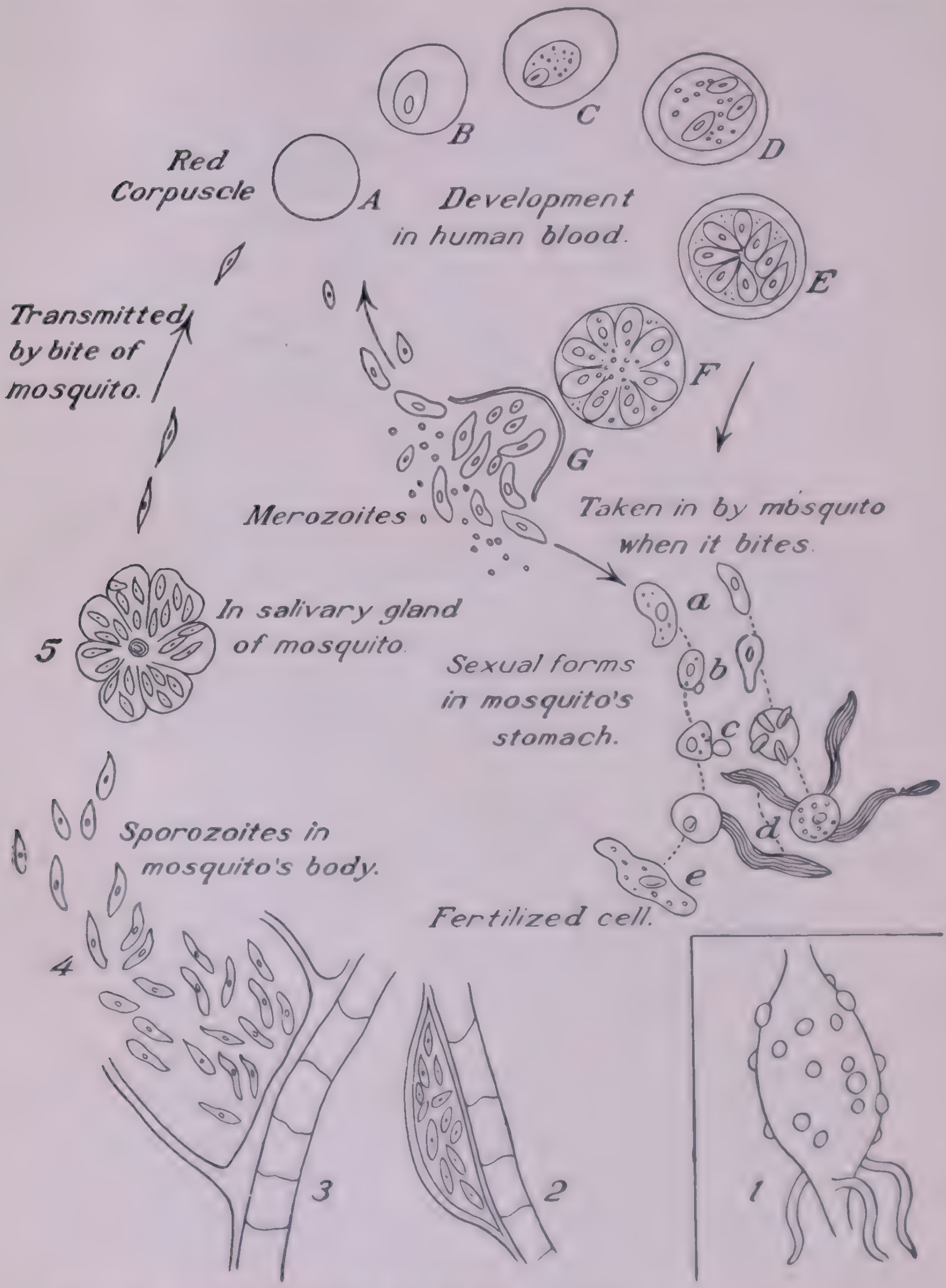

B
C
D
Red Corpuscle
A
Development in human blood.
E
Transmitted by bite of mosquito.
F
G
Merozoites
Taken in by mosquito when it bites.
a
5
In salivary gland of mosquito.
Sexual forms in mosquito's stomach.
b
c
d
Sporozoites in mosquito's body.
e
Fertilized cell.
4
3
2
1

Fig. 145. — Life history of the malarial parasite in man and mosquito
1, 2, 3, parasites on outer wall of mosquito's stomach.

as it was in Prussia. To do this, first find the average annual death rate in Austria for the years 1875 to 1884. Subtract from this the average annual death rate in Prussia for the same years. What does this difference represent? The population of Austria in 1880 was about 22,000,000. Remembering that the death rate means the number of deaths per hundred thousand inhabitants, estimate the number of lives that might have been saved by vaccination during the years 1875 to 1884, taking the above figures as the average population.

INSECTS AS CARRIERS OF DISEASE

The mosquito. *Harm done.* It has been definitely proved that mosquitoes carry malaria and yellow fever and that they are the only means by which these diseases are carried. One kind carries malaria, and another kind yellow fever. A mosquito first stings a sick person and sucks up blood in which are found the organisms that cause the disease. These organisms undergo a change within the insect's body and develop spores. Later when the insect stings a well person, it leaves in the wound some of these small spores, which may increase in numbers and cause sickness in the second person.

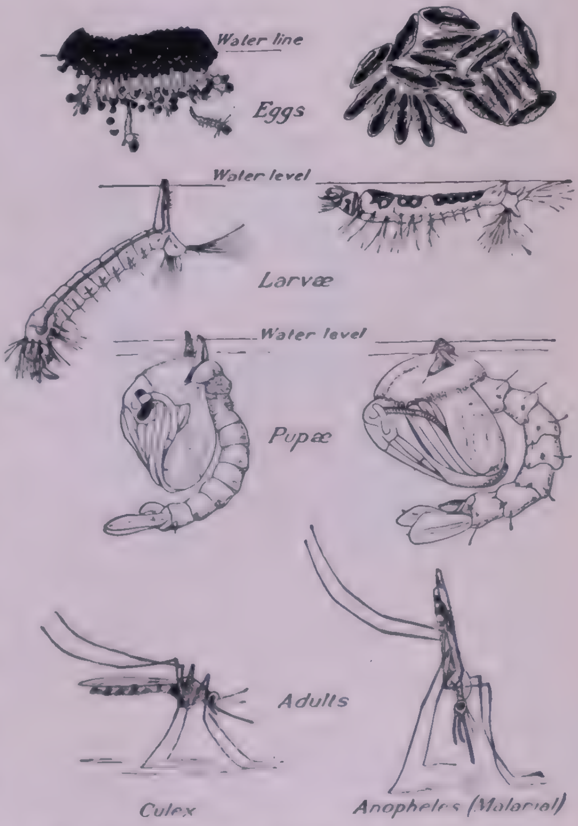


Fig. 146. — Life history of common mosquito (Culex) at left and of malarial mosquito (Anopheles) at right

Notice how they differ in each stage.

Control of mosquito. Hence the chief method used to control these two diseases is to fight mosquitoes. The most effective measures are applied against the breeding places, which are quiet bodies of water. Two kinds of measures may be employed: first, the preventive, the purpose of which is to prevent the breeding of mosquitoes; and second, the remedial measures, the purpose of which is to destroy those mosquitoes that may be breeding. The first remedy is the more important, because it is lasting in its effects; but the second serves as a valuable temporary substitute.

Preventive measures. Among the first class of measures are the following: In large marshes, draining by means of ditching is effective. Work of this kind on the salt marshes of California and New Jersey has been carried on over large areas with marked success. Not only has the mosquito nuisance been abated, but the value of the land for agricultural purposes has been increased. Some ponds may be drained, and small woodland pools may be filled with soil.

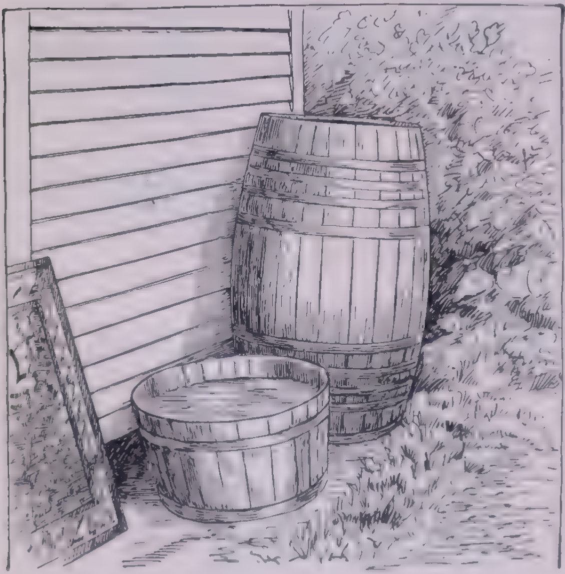


Fig. 147. — Rain barrels — breeding places for mosquitoes — should be kept covered

The breeding of mosquitoes in cisterns, tanks, barrels, etc., may easily be prevented by covering them with mosquito netting or with boards.

Empty cans and bottles that accumulate in yards or dumps should be turned over so that they will not hold water. Better still, these should not be allowed to accumulate. There may be frequent community housecleanings during which the cans are collected and buried.

Remedial measures. Fishes may be introduced into ponds to feed upon the water stages of the mosquito. The swampy margins should be deepened to allow the fishes access to all parts.

On small ponds and pools kerosene may be applied to the surface at the rate of one ounce to fifteen square feet. This stifles the larvæ and pupæ and also destroys many of the adults which come to lay eggs. To be most effective this must be applied frequently, as the film is easily destroyed by rain or wind.

Successful campaigns against the mosquito. Mosquitoes can be controlled and the injury they do largely prevented by the intelligent coöperation of the people of a community. There are many cases where efforts of this kind have met with remarkable success. Two of the most successful cases were those under the charge of the United States government in Cuba and Panama.

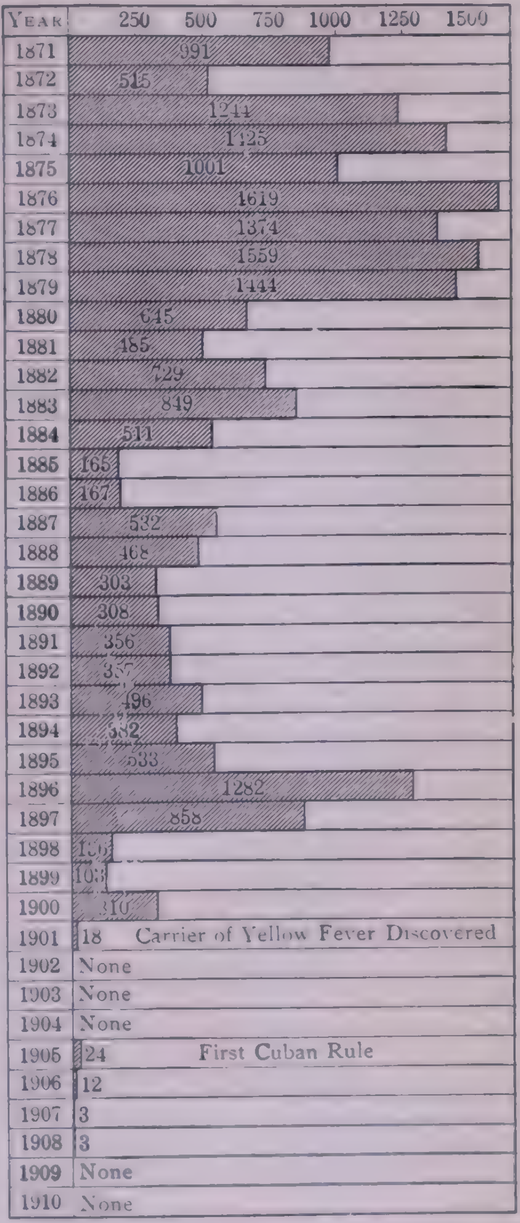


Fig. 148. — Showing death rate from yellow fever in Havana before and after the discovery that mosquitoes carry the disease

At the close of the Spanish War, the American soldiers under charge of General Gorgas made a campaign against the mosquito in Havana and the immediate vicinity. As a result of this work, yellow fever was wiped out in Havana, and the number of deaths from malaria was reduced to one half the first year and to one quarter the second year; and there has been still further decrease in later years.

Previous to the digging of the Panama Canal, General Gorgas was appointed sanitary officer of the Canal Zone. He employed similar methods against the mosquito there, with the result that yellow fever was practically eliminated and malaria greatly reduced. This work had a very important bearing on the building of the canal, which would undoubtedly have been seriously interfered with if this work of General Gorgas in doing away with the mosquito had not first been done.

In more recent years the fight against the yellow fever mosquito has been continued, with the result that the disease has been entirely eliminated from North America and has been so greatly reduced in South America that it is now found in only a few localities.

The house fly. Until recently the house fly has been considered merely a source of annoyance, but investigations of the past years have proved that it is a source of danger as a means of carrying diseases.

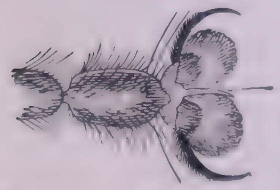


Fig. 149. — Foot of fly, a germ carrier

Harm done. The method by which it carries these is very different, however, from that of the mosquito in carrying malaria and yellow fever. The kinds of diseases usually carried by the flies are those that may be taken into the system through food and drink. The fly breeds in filth and frequents filthy places. As it walks over these places, there adhere to its feet and the hairs on its body small particles of filth, which often contain those bacteria that cause disease; and still other bacteria may be sucked up through its proboscis and taken into its digestive system.

The fly may then enter our homes or places where food is sold; as it alights on the food or falls into the milk, it leaves some of these bacteria, either in the particles of filth that fall from its body or in the flyspecks deposited. When the food is eaten, these germs are taken into the human system and may produce disease.

Demonstration 50

Purpose. To show that flies carry bacteria.

Materials. Two Petri dishes; two tubes of culture medium.

Directions. Melt some culture medium and pour into a sterilized Petri dish. Cover. When the medium hardens, place a fly under the cover and allow it to walk on the medium. Then let it escape, and cover the dish. Prepare another dish of culture medium; cover it, but do not allow a fly to walk on it. Allow the dishes to stand side by side for several days, and notice any differences.

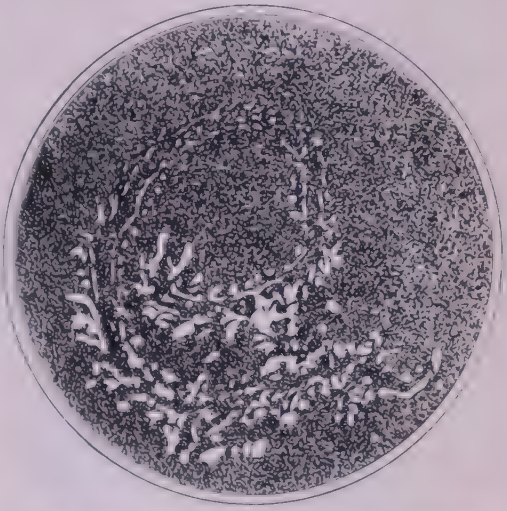


Fig. 150. — Fly tracks on a culture

Life history of the fly. The most common breeding place of flies is horse manure. They breed also in almost any decaying animal or vegetable matter. Examination of manure piles has shown that on the average a pound of manure may have from five hundred to a thousand larvæ in it. The fly in its development passes through the four stages of egg, larva, pupa, and adult. About 120 eggs are laid at a time by one female, and this process may be repeated several times in a season. The eggs hatch in a day or less; the larval stage, the maggot, lasts from five to six days; and the pupal stage, from five to seven days.

Thus the entire period of development takes from ten to fourteen days, being more rapid in the warmer seasons and climates.

The females begin to lay eggs in from ten to fourteen days after coming out of the pupal state. Egg laying begins in the spring and continues till the cold days of autumn. During this period it is possible to have from eight to twelve generations. It is thus seen that the possibilities of increase during a single season are enormous. While most of the flies die on the approach of cold weather, a few live through the winter, some as adults in cracks and crevices of buildings and a few in the puparium state.

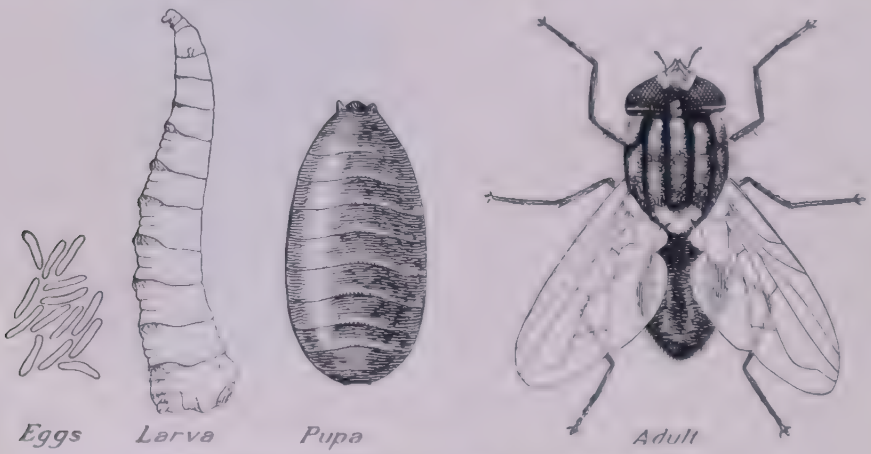


Fig. 151. — Life history of the house fly

Control of the house fly. The most effective fly campaign requires the coöperation of citizens, health officers, and town authorities. It is naturally the duty of the health officials to take charge of the work; the aid of the city authorities is needed to furnish the funds to carry on the work; and the intelligent coöperation of the citizens is necessary in carrying out the ordinances of the health officials. Often the first steps may be taken by civic organizations. The newspapers have always proved a great help in the campaign of education that is usually needed to arouse the citizens.

Remedial measures may be directed along two lines: first, to prevent the breeding of flies; and second, to furnish protection against the flies that do exist. The most important remedies, because the most lasting, are those directed toward the first end. As horse manure forms the breeding place for from 90 to 95 per cent of the house flies, the chief thing is to prevent flies from breeding there. Two methods may be used — first, to remove the manure frequently, and second, to keep the manure in tight bins or receptacles, so covered or screened that the flies cannot enter. The bin should be emptied every week. For a single horse, a barrel with a tightly fitting cover serves as a good receptacle. In order that this method may be effective, it is necessary that all stables take the same precautions. A single manure pile uncared-for will furnish enough flies to infest a whole neighborhood, for flies will usually travel a quarter of a mile from their breeding places. A covered bin does not entirely prevent flies from breeding in the manure, but nevertheless it is better than an open manure pile.

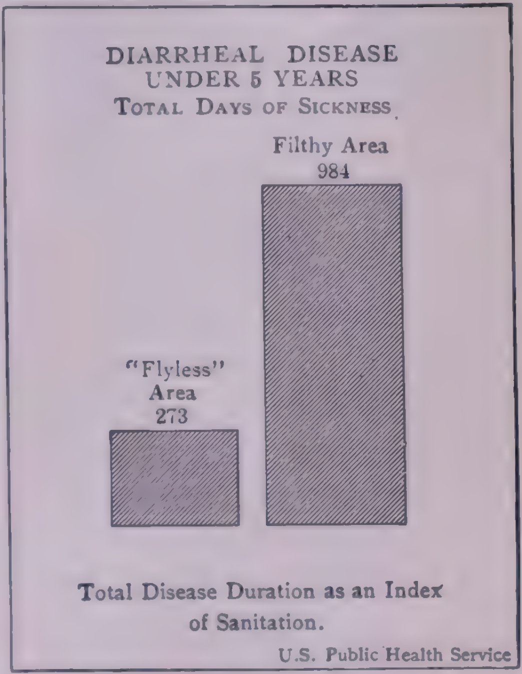


Fig. 152. — **Effect of doing away with flies on prevalence of this children's disease**

In the country and in towns where there is no sewer connection, it is important that sanitary privies be used to prevent the access of flies to human excrement, and that the privies be screened. No filth of any kind should be allowed to accumu-

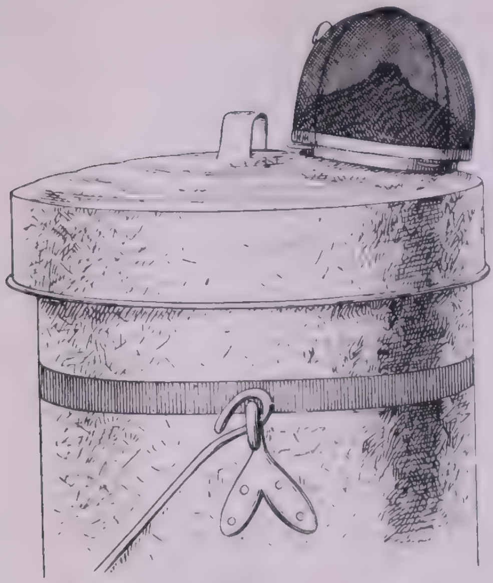


Fig. 153. — Hodge fly trap

late about the buildings. Garbage cans should be tightly covered and frequently emptied.

Curative measures. Although the preventive measures are the more important, until they are in effective operation much can be done through curative remedies. These may be directed along two lines: first, to kill the flies and the larvæ; and second, to screen one's self and one's food from the flies. Numerous experiments have been tried in treating manure piles with chemicals to kill larvæ and pupæ. One of the best substances is borax. This is spread on the manure pile as a powder, and then the pile is sprinkled with water, which dissolves the borax. This solution kills the larvæ and the pupæ. About a pound a week is required for one horse.

Something may be done through the use of fly traps. The bait box should be large and should be filled with something that will attract flies. One effective trap has been invented that is placed over a hole in the cover of a garbage can. (See fig. 153.)

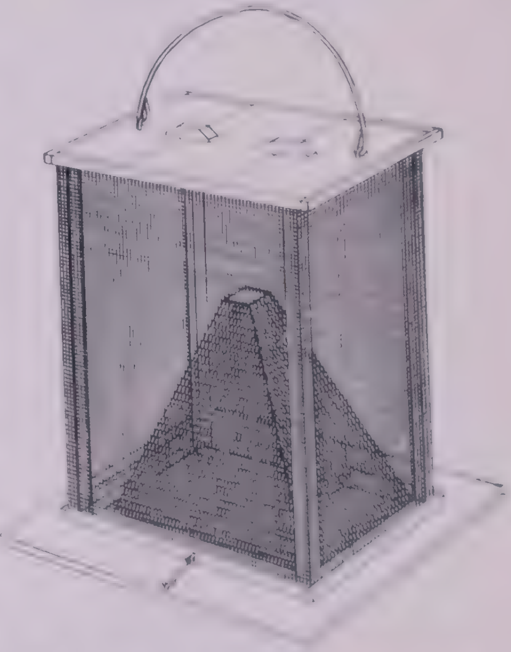


Fig. 154. — A fly trap easily made

It is possible also to poison flies. One of the best preparations for this purpose is formalin. The weak solution used is not dangerous to human beings but is very effective in poisoning flies. A 2 per cent solution should be used, made by adding two tablespoonfuls of the solution as bought at the drug store to a pint of water, or water and milk.

As a protection against the flies that are not killed, the doors and windows should be well screened. A piece of sticky fly paper placed on the outside of the screen door will catch many flies which otherwise would enter the house when the door is opened.

All food when not in use upon the table should be screened or placed where flies cannot reach it. People should trade only at those bakeries, fruit stands, and grocery stores that keep the food offered for sale well screened from flies.

OUTLINE SUMMARY

Communicable Diseases

I. Bacteria and health
II. Characteristics of bacteria
    1. Size
    2. Multiplication
    3. Occurrence and food
    4. Conditions of growth
III. Relation of bacteria to disease
    1. How bacteria leave the body
    2. How bacteria are distributed
    3. How bacteria enter the body
IV. How to control diseases
    1. Smallpox and vaccination
        a. Effect of vaccination on death rate
    2. Diphtheria
        a. Antitoxin treatment
        b. Toxin-antitoxin treatment
        c. The Schick test

3. Typhoid fever
    - *a.* How spread
        - (1) Water
        - (2) Carriers
        - (3) Food
    - *b.* Vaccination
4. Tuberculosis
    - *a.* How bacteria leave and enter the body
    - *b.* Bacteria in foods
    - *c.* Public drinking cups
    - *d.* Cure
        - (1) Window tent
    - *e.* Prevention of tuberculosis
        - (1) Care of sputum
        - (2) Protection of food
        - (3) Anti-tuberculosis movement
        - (4) Sanatoriums

V. Insects as carriers of disease
1. The mosquito
    - *a.* Harm done
    - *b.* Control of mosquito
    - *c.* Preventive measures
    - *d.* Remedial measures
    - *e.* Successful campaigns
2. The house fly
    - *a.* Harm done
    - *b.* Life history
    - *c.* Control of the house fly
        - (1) Preventive measures
        - (2) Curative measures

QUESTIONS FOR CLASS DISCUSSION

1. How can such small organisms as bacteria have so much influence on human life?

2. What is the relation of temperature and moisture to the growth of bacteria?

3. What are the chief means by which disease bacteria leave the body?

4. How may they enter the body?

5. What are the chief means by which disease bacteria are carried from one person to another?

6. How does the treatment for diphtheria differ from that for smallpox?

7. What are the evidences of the effectiveness of vaccination for smallpox and of the antitoxin treatment for diphtheria?

8. Is compulsory vaccination advisable?

9. What are the chief things to do in order to be protected from typhoid fever?

10. Compare vaccination for typhoid fever with vaccination for smallpox.

11. Where should the chief emphasis be laid in the control of contagious diseases?

12. What are the chief things to be done in the control of tuberculosis?

13. What can you do to help in the fight against contagious diseases?

14. Which is the more dangerous animal, the fly or the mosquito?

15. Show why it is necessary to understand the life history of the fly and the mosquito in order to fight them successfully.

16. What measures against the fly and the mosquito require the coöperation of all the people concerned?

17. What measures can be taken by each individual, without regard to what his neighbors may do?

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CHAPTER XXIV

THE PUBLIC WATER, MILK, AND FOOD SUPPLY

1. What may a community do to protect its water supply?
2. Why should the milk supply of a city be carefully inspected?
3. In what ways may foods be made unfit to eat?

THE WATER SUPPLY

The first and most important duty to which a community should give its attention is the protection of its health. One of the first things to do is to obtain a pure water supply. As all people in a city use water from the same source, an impure water supply affects everyone in the community. The chief kind of impurity against which the water must be protected is the disease germ. Two of the commonest of these germs found in water are those that cause typhoid fever and dysentery. Many cases of these diseases have been due to impure water.

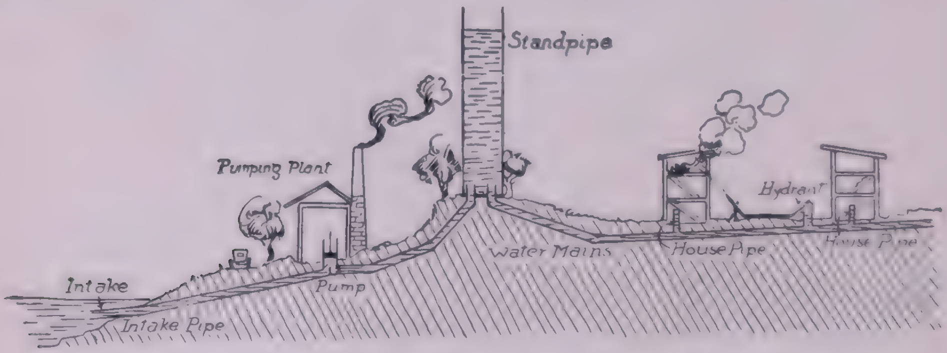

Fig. 155. — Water supply system for towns and cities

How water is made impure. Disease germs may get into drinking water in a number of ways. In every case some person is the source of the germs, which are given off in the wastes of the body. Sometimes the sewage containing these germs may empty into a river, and then the water from this river may be used as drinking water by a city situated further down the river, as on the Merrimack River in New England. A city may discharge its sewage into a lake and take drinking water from the same lake near the sewer outlet, as was formerly done in Two Harbors, Minnesota.

Even the water of a deep well has been known to be made impure by a leak in the water pipes, through which sewage entered when a flooded condition of a river brought the river water in contact with these pipes, as happened some years ago in Mankato, Minnesota.

In Plymouth, Pennsylvania, an epidemic occurred because a family living on the banks of the stream from which the town took its water had thrown the wastes from a typhoid patient on the snow near the stream. When this melted, the germs were carried into the stream.

All these cases go to show how important it is to prevent pollution of the water supply, because typhoid is a preventable disease, due to carelessness, and many cases may be avoided by keeping the water supply pure.

The selection of a proper location is important in protecting a water supply. Wells, pumping apparatus, exposed suction mains, reservoirs, and filters should be located where they will not be subject to flooding with surface water during high water periods.

Water supplies may be divided into two classes: surface supplies and underground supplies.

Purifying water supplies. *Surface* water supplies are those obtained from lakes and streams; they should not be considered safe for drinking purposes without purification. It is practically impossible so to prevent the pollution of surface waters that their sanitary quality will be wholly satisfactory at all times. The application of some form of purification to water which is not grossly polluted renders it safe for drinking purposes and makes possible a definite control of the quality of the water at the point where it is purified. The simplest method of purifying water in small quantities is to boil it; it may also be purified by the application of certain chemicals such as chlorine, calcium hypochlorite, iodine, etc.

Treatment with chemicals. Chlorination is accomplished by adding chlorine to the water as a gas, as a chlorine solution, or as calcium hypochlorite. This is the simplest method now in use for the purification of public water supplies. Liquid chlorine is now almost universally used for this purpose in the treatment of public water supplies. The chlorine gas is compressed into liquid form in metal cylinders, which can be transported to the plant where it is to be used. These drums are attached to an apparatus which controls the administration of the chemical to the water, either in the form of a solution or directly as chlorine gas. Chlorine treatment should be limited to waters that are practically free from suspended material and do not contain excessive quantities of unoxidized substances. Water that contains appreciable quantities of such substances should be subjected to filtration before it is chlorinated.

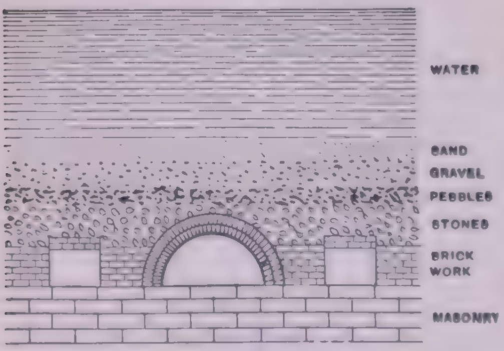

Fig. 156. — Cross section of a sand filter

Filtration. The process of filtration which is most commonly used in this country is accomplished by means of a mechanical gravity filtration plant. To the water is first added a chemical that forms other substances that envelop the suspended material in the water and carry it to the bottom of the coagulation basin.

The water passes from this basin to the filters. These usually consist of approximately three feet of sand and gravel or crushed rock. These materials are graded so that the fine sand is on the surface and the gravel or crushed rock is at the bottom, the latter overlaying underdrains that receive the filtered water and carry it to the clear-water basin. The treatment up to this point should remove the suspended material and a large part of any color that may be present in the water, and should materially reduce its bacterial content. It is almost universally the practice at the present time to apply chlorine to the water as it leaves the filters or at some point previous to its distribution for public consumption, in order to kill any

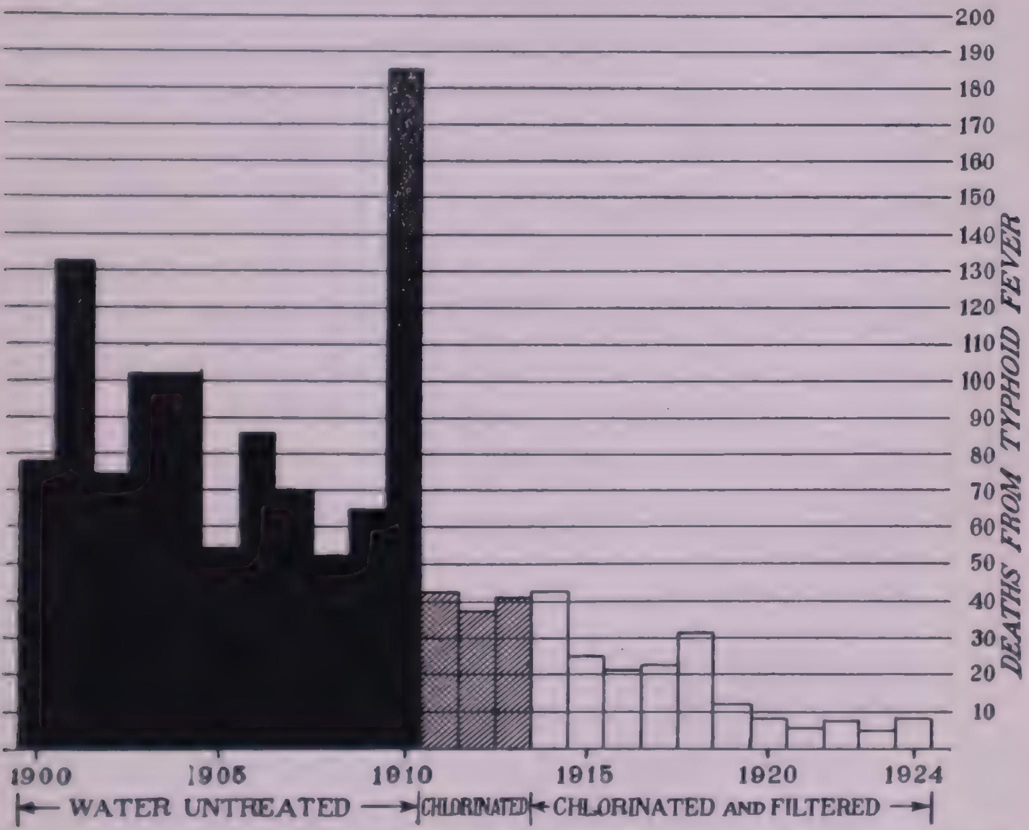

Fig. 157. — Effect on typhoid fever of chlorinating and filtering the drinking water of Minneapolis, Minnesota

disease-producing germs that may have passed through the plant.

Underground water supplies are obtained from dug, bored, driven, or drilled wells and from springs. Such supplies can be made safe for drinking purposes provided they are properly located, constructed, and operated. (See Chapter VI.)

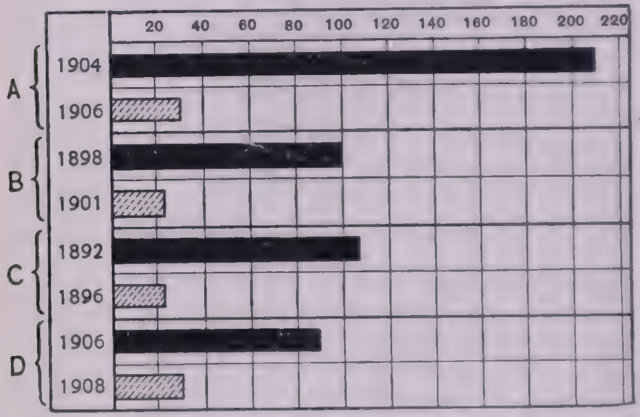

Fig. 158. — Cases of typhoid per hundred thousand inhabitants before filtering water supply (solid) and after (shaded)

_A_, in Watertown, N. Y.; _B_, in Albany, N. Y.; _C_, in Lawrence, Mass.; _D_, in Cincinnati, Ohio.

The chlorination treatment of water is widely used and has proved very effective in many cities in lowering the death rate from typhoid fever.

As an illustration of how a city may reduce the death rate from typhoid fever by purifying its water supply, reference is made to the experience of Minneapolis, Minnesota. In 1910 chlorination of its water supply was begun. In that year the number of deaths from typhoid fever was 185; in the following year it fell to forty-two. In 1913 a filtration plant was added. The number of deaths from typhoid fell from forty-one in 1913 to twenty-six in 1915; and it has since gradually been decreasing till in 1924 there were only nine deaths from this disease. In the four years preceding the chlorination of the water supply the average number of deaths each year from typhoid fever was sixty-nine; for the four years from 1921 to 1924 the average number was seven. The experience of Minneapolis is taken merely as an example of what is being done in many other cities.

DEMONSTRATION 51

Purpose. To see what kinds of water contain the fewest bacteria.

Materials. See Demonstration 48 and read "1" under "Directions."

Directions. 1. Obtain several samples of water — some from the faucet, some from a well, some from bottled water, some from melted snow, some from a river, some from the street gutter.

2. Take as many culture tubes as the samples of water to be tested, place them in a dish of water, and heat the water till the agar melts. By means of a sterilized pipette introduce one cubic centimeter of each sample of water into a test tube, one tube for each sample. Shake the tubes so as to mix the water thoroughly; then pour the culture medium from each tube into a sterilized Petri dish, covering at once. Put a piece of gummed paper on each dish and label the source of the water.

3. Allow to remain at ordinary temperature for two or three days. Count the number of colonies that appear. This represents the number of bacteria in the cubic centimeter of water. Which sample contained the most? Which the least?

HOME PROJECT 12

Purpose. To read the water meter and compute the weekly cost of water.

Directions. 1. If you have connections in your home with a supply of running water, read your water meter. If you have the straight-reading register, copy the figures found there. If you have a dial-reading register, make a drawing in your notebook of your meter. Draw each circle, copying the figures, and draw the pointer in its proper place with reference to the figures. Bring the drawing to school, so that the teacher may explain how to read the meter.

2. One week later, make another reading and subtract the first reading from the second. Find the price charged for water and estimate the cost of one week's supply.

MILK

Use of milk. Because it is a fundamental and essential article of diet, milk is used more extensively than almost any other food. It is used by almost every person every day. The amount consumed daily in the United States averages about a pint for each person. One sixth of this amount is used by infants and children. Practically every normal child before it is one year of age receives at least one pint of milk a day. The extensive use of milk, with the consumption rapidly increasing, makes it readily appreciated that the milk supply of a city is a matter of public concern.

Dangers from impure milk. While milk is one of the best foods that we have, it is also a substance most favorable to the growth of bacteria; hence great care should be taken to see that milk is safe to use. Milk is a common means of carrying disease germs and producing epidemics. An investigation made by the surgeon-general of the United States Public Health Service showed that at least five hundred epidemics in this country had been traced to impure milk. Of these epidemics, 317 were of typhoid fever, 125 of scarlet fever, and 51 of diphtheria. Tuberculosis and septic sore throat germs also may be carried by milk.

Tuberculosis, one of the most common diseases affecting the human family, is also one of the most common diseases of dairy cows. It is estimated that in many sections of the country more than 10 per cent of the dairy cattle are affected with this disease. It is universally recognized that tuberculosis in cows may be directly transmitted to man through milk. Statistics show that approximately 7 per cent of all tuberculosis in human beings and as much as 25 per cent of tuberculosis in children under sixteen years of age is contracted from the use of milk obtained from tuberculous cows.

How milk may carry diseases. While cows may be a means of giving the disease to man directly through milk, many of the disease germs found in milk are introduced through carelessness after it is drawn from the cows. Some epidemics of typhoid fever have been due to the fact that the milk cans were washed in water containing the disease germs, which grew and multiplied in the milk.

An epidemic of diphtheria in one city was traced to a man with a light case of diphtheria, who was working in a dairy. In another city an epidemic of typhoid fever was found to be due to the fact that three people living in a house connected with a dairy had typhoid fever. The dairy utensils were washed and handled in the house by the people who had the disease.

Supervision of milk supplies. The dangers from milk can be removed by effective supervision of the supply. In the larger cities where health departments have established such supervision, disease epidemics from impure milk have been done away with. It is only in the cities where the authorities have not given this matter the attention it deserves that milk-borne epidemics still occur. In order to preserve the public health, every city should adopt and enforce an ordinance regulating the production and handling of its milk supply. Unless there is such an ordinance and it is properly enforced, there is no assurance that the milk is safe. Consumers should inquire into the provisions which their city makes for protecting the milk supply, and they should insist upon the enforcement of a proper milk ordinance.

The chief food of babies is milk, and many thousands die every year on account of impure milk. In the city of Rochester, New York, nearly a thousand children under five years of age died in 1892. The city began an inspection of its milk supply, and as a result the number of deaths of young children decreased to less than five hundred during 1896, although the city had increased in population. Inspection of the milk supply reduced the number of deaths one half and saved each year the lives of five hundred children in this city alone.

Health authorities recognize two classes of safe milk: (1) raw milk produced and handled under conditions similar to those required for certified milk, and (2) pasteurized milk.

Certified milk. Certified milk is the freshest, cleanest, and safest grade of raw milk that is produced, and it is intended especially for babies and invalids. It is obtained from healthy cows at dairies where the highest standards of cleanliness prevail. It is milked and handled by dairy workers who are free from communicable diseases. Certified milk is bottled and sealed at the dairy and is kept at a low temperature until delivered to the consumer. Its production is surrounded with every possible safeguard for preventing the entrance of bacteria that produce disease or decompose milk.

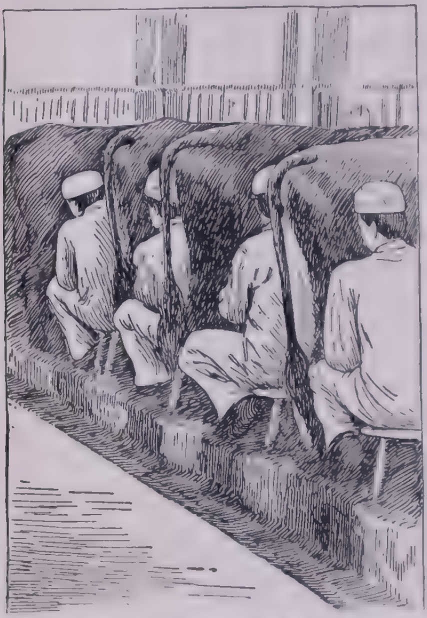

Fig. 159. — Sanitary milking
Pail scalded, cow groomed, milk-bag wiped, hands washed.

The standards prevailing in the state of Minnesota require careful examinations of the cows, frequent sanitary inspections of the dairies, the medical examination of the dairy workers, and regular examinations of the milk.

Pasteurized milk. Pasteurization, properly performed, is universally recognized by health authorities as the most economical and effective method of rendering milk safe. It is now agreed that all market milk should be pasteurized, unless it has been produced and handled under conditions similar to those required for certified milk. Pasteurization is not intended as a substitute for lax or unclean methods of production, but its purpose is primarily to overcome certain dangers in raw milk which even the most highly developed systems of dairy inspection may not remove.

Meaning of term "pasteurization." "Pasteurization" means heating milk to a temperature of not lower than 145 degrees F. for not less than thirty minutes. Following this, it is promptly cooled to 50 degrees F., or below. Pasteurization under this method does not kill all the bacteria in the milk, but it does kill those that may cause disease. A number of types of harmless, desirable bacteria that cause milk to sour are not killed by this heating process, so that pasteurized milk sours in the same manner as raw milk, although the time it remains sweet is prolonged about twenty-four hours.

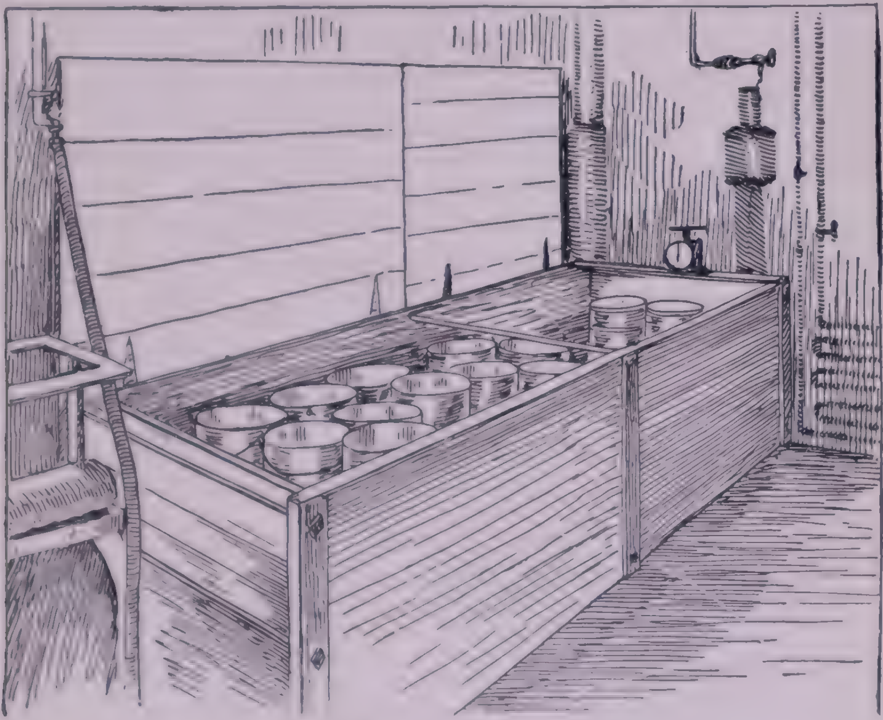

Fig. 160. — Cooling milk

This should be done as soon as the milk is drawn.

Pasteurization as carried out at the present time causes no appreciable chemical changes; the milk tastes practically the same as raw milk; and the food value is not materially affected.

Effect of pasteurization on vitamines. Milk contains all three of the vitamines—A, B, and C—and the effect that pasteurization may have on them is of importance. Fat soluble vitamine A and water soluble vitamine B are quite resistant to heat, and it is agreed that pasteurization has little or no effect upon them. Vitamine C is sensitive to heat at about 122 degrees F. However, since adults do not depend on milk as a source of vitamine C, pasteurization cannot be said to have a harmful effect on the food value of milk in so far as they are concerned.

Pasteurization a health measure. Since proper pasteurization gives marked protection against communicable diseases, there is no longer any question as to the value of the process from a health point of view. In cities where all of the supply is pasteurized, milk-borne diseases have been practically eliminated. The United States Department of Agriculture states that "No epidemic of disease has ever been traced to properly pasteurized milk." Pasteurization is also an important economic measure, for it would be impossible to obtain a safe raw milk supply for a city of any considerable size at a price within reach of the average consumer.

Extent of pasteurization. Appreciation of the need of pasteurization and of its value as a health measure is shown by the marked increase in pasteurization in the United States. An average of more than 95 per cent of the milk is pasteurized in the cities in the United States with a population of five hundred thousand or more. In Minnesota an average of more than 50 per cent of milk is pasteurized in cities with a population of five thousand and over. Every year shows an increase in the number of pasteurization plants and in the amount of pasteurized milk consumed.

Supervision of pasteurization. In order to pasteurize milk effectively the required rules for heating, holding, cooling, and subsequent handling must be strictly adhered to. It is too important a health measure to leave entirely to the dairymen, and no milk should be permitted to be sold or labeled as pasteurized unless the process has been properly carried out. The protection afforded by the pasteurization of milk depends to a large degree on the methods of supervision and control provided by the local health authorities.

DEMONSTRATION 52

Purpose. To compare the cleanliness of milk from different sources by estimating the number of bacteria in a cubic centimeter (cc).

Materials. Several samples of milk. See Demonstration 48 and read "1" under "Directions."

Directions. 1. Pour 100 cc of water into a flask and boil for ten minutes. When the water cools add 1 cc of milk and shake thoroughly.

2. Melt a tube of culture medium. Into this put one drop of the diluted milk. Shake it thoroughly. Pour it into a sterilized Petri dish and cover it.

3. Allow it to stand for four days; then count the number of colonies. Each colony started from one bacterium. Estimate the number of bacteria in 1 cc of the undiluted milk, remembering that about 15 drops make a cubic centimeter and that 1 cc of the milk was diluted with 100 cc of water.

4. Prepare several tubes and dishes, putting in milk from different sources. Also take milk from the same sample after it has stood for a day, because the number of bacteria depends on the age of the milk.

DEMONSTRATION 53

Purpose. To try the effect of pasteurization on the keeping quality of milk.

Materials. Beaker; test tubes; thermometers.

Directions. Fill the beaker half full of water; fill the test tube half full of milk. Put the test tube in the beaker. Heat the beaker and put the thermometer in the water. Regulate the flame so as to keep the temperature between 145 and 160 degrees for about a half hour. Take out the tube and plug its mouth with cotton batting. Fill another tube half full of milk and plug it with cotton. Allow the two tubes to stand side by side for several days; notice how long the milk in each keeps sweet.

FOODS

Since most of our foods are bought from public supplies, it is not possible for each individual to determine for himself the conditions under which foods have been prepared. It is necessary, therefore, to have these matters controlled by laws and to have foods examined by men who make it a business to inspect them.

Diseased foods. In order to know how best to protect our food, we must first know what some of the impurities are that are found in foods. Foods may be diseased or decayed. For example, if cattle that have had tuberculosis are killed and sent to market, the meat contains the germs and is dangerous as a food. In the preparation and marketing of foods, they may be polluted with germs through exposure to dust and flies or by being handled by people who are diseased. Food may be kept so long before being sold to the consumer that it begins to decay; as a result there may be formed certain poisons which may cause serious sickness and even death.

Adulteration. The three kinds of adulterations most commonly practiced are: first, the mixing of some cheaper material with the original substance; second, the addition of coloring matter; and third, the use of chemical preservatives to keep foods from decay.

Mixture. The substances used as adulterants are generally not harmful to the human system; the chief objection to adulterants lies in the fraud thus practiced. Ground coffee may be adulterated with chicory, ground peas, beans, etc. Unground coffee is adulterated less frequently. Butter may be mixed with oleomargarine. Water may be added to milk, or the cream may be removed. Flavoring extracts and spices are very frequently adulterated.

Coloring matter. There are different opinions as to whether there are ill effects in the body from all of the materials used for coloring foods. But regarding the effect of many of them there is no doubt, as they are known to be injurious. There remains, however, the fraud, as these colors are used to give a false appearance to the foods containing them. Coloring matters may be added to jellies made from cheap substances, so as to give them the same appearance as those made from good fruits They may be added to cucumber pickles and tomato catsup to bring back the original color which has been lost in the process of canning. Butter is often artificially colored. Chopped meats which are not fresh may have coloring matter added to give them the appearance of fresh meat.

Preservatives. The most dangerous kind of adulteration is the use of chemical preservatives, because most of those used are injurious to health. Among the more common kinds are formaldehyde and benzoic, boric, and salicylic acids and their sodium salts, such as benzoate of soda.

Milk is sometimes treated with preservatives, especially in warm weather, to delay its souring. Formalin is the substance most often used for this purpose. Milk is the chief food of infants, and therefore it is specially important that it should be pure and wholesome. At that early time in life, these preservatives are particularly dangerous to health. Impure milk is an important factor in the large infant mortality in our large cities. An official of the Health Department of New York City said, "No doubt, if we could get pure milk, mortality of infants would decrease 50 per cent."

One of the chief arguments against the use of all kinds of coloring matters and preservatives lies in the fact that their use makes it possible for substances to be canned and sold that are unfit for food. For instance, in the canning of tomatoes and catsups, if the substances are allowed to stand too long or are not cared for in a clean way the mixture ferments and becomes unfit for food. But by the use of some preservatives the fermentation may be stopped, and by adding coloring matter the original color may be restored; then the mixture may be canned and sold. In outward appearance it may seem like good clean food, while in reality it is unfit to be eaten.

Condemned foods. Unfortunately the marketing of spoiled foods is more frequent than is commonly suspected. In the state of Missouri during the year 1912 the food inspectors condemned and destroyed, as unfit for use, the following foods which were offered for sale: 20 pounds of candy; 80 cans of unwholesome milk; 125 pounds of spoiled beans; 134 bottles of olives; 135 packages of breakfast food; 316 cans of decaying canned food; 581 bottles of impure patent medicines; 741 pounds of meat and fish; 12,000 pounds of hominy; 1,885 cans of bad fruits and vegetables; and 225,000 eggs.

In New York City 362,795 pounds of groceries and canned goods were destroyed in 1907 because they were unfit for use. In 1902 in the same city 12,000,000 pounds, or 6,000 tons, of unfit food were destroyed.

The Secretary of Agriculture estimated that in former years the sale of adulterated food in the United States amounted to over a billion dollars ($1,175,000,000), or about 15 per cent of our entire commerce in foods. Probably the conditions are much better now.

United States Pure Food Law. When people realized the injury that was being done them through these impure foods, they took steps to protect themselves by law. In 1906 the United States government passed the Pure Food Law. This law does not forbid the use of all preservatives and coloring matters, but it requires preparations put up in bottles, cans, and other packages, intended for shipment to other states, to bear a label stating the materials contained and the proportion of each. One often sees the inscription on foods and drugs: "Guaranteed under the United States Food and Drugs Act, June 30, 1906. Serial No. ——." This inscription is often misunderstood to mean that the product has been examined by government inspectors and its purity and the correctness of the label guaranteed. Such, however, is not the case. The statement on the label is merely the guarantee of the manufacturer, not of the government, under this act.

This law was important in that it established the principle that the government has the right to regulate the manufacture and sale of foods. It enables one to know what is inside the package and is, of course, a check on many dishonest manufacturers. Under the federal act, arrangements were made also for the appointment of inspectors to examine meat in certain establishments. This federal meat inspection covers only meat intended for shipment to other states. State supervision is needed to look after meat intended for local consumption. Some steps have already been taken along this line, and most of the states are passing and enforcing laws to protect us from impure foods.

United States Division of Foods. Much of the credit for these investigations into the purity of our food supply is due to the Bureau of Chemistry, which is a branch of the United States Department of Agriculture. About thirty years ago, Dr. Wiley, the former chief of this bureau, began an investigation of food adulteration. Since then this work has grown in importance; and about ten years ago the food laboratory was made a sub-branch of the Bureau of Chemistry and called the Division of Foods, with a force of about twenty-five men devoted entirely to the study of foods. The results of the investigations made by the Bureau of Chemistry have instructed and awakened the people of the country and have thus helped to make possible the food laws that have been passed.

City ordinances. Many cities are passing local ordinances regulating sanitary conditions in the butcher shop and the bakery where bread and other foods are made or handled, and requiring the covering of fruits and bread with screens to keep off the flies. It is desirable to require that cooked foods be kept in dustproof receptacles, for dust may be one means of transmitting disease germs. Under ordinary city conditions many dust particles fall on food left exposed.

Culture plates exposed under a glass case in a bakery collected fifteen bacteria in ten minutes, while a plate exposed on the open counter collected eight hundred bacteria in the same length of time. A culture exposed on a sidewalk fruit stand collected ten thousand bacteria in ten minutes, nearly seven hundred times as many as a culture under cover. Only those stores should be patronized that keep their food covered. Sometimes bread is wrapped at the bakery in paper, and this helps to keep it clean. A bacteriologist who made an estimate of the number of bacteria on a loaf of bread found an average of 7,500 bacteria on a loaf of unwrapped bread and only 585 on a loaf of wrapped bread.

COMMUNITY PROJECT 1

Purpose. To investigate local conditions with reference to water, milk, and foods.

Directions. 1. The class may divide itself into three committees — a water committee, a milk committee, and a food committee. Each committee will investigate the local conditions with reference to its topic and report to the class. The water committee will collect information regarding the source of water supply, the possibility of pollution, the means taken to purify the water or to prevent pollution, the means of distribution, the cost, the measurement of water used, and further steps needed to protect the water supply. If possible the committee may visit the filter plant or the pumping station.

2. The milk committee will collect information regarding the source of milk, the sanitation of dairies, pasteurization plants, inspection given by the city, conditions under which licenses are granted, and the need for further care on the part of the city. They may perhaps visit some of the dairies and report on the conditions found.

3. The food committee may investigate the source of the foods used in the town, the inspection given foods by federal, state, and local authorities, the local ordinances, the care exercised by local dealers in handling the food supply, and other steps that should be taken to protect the food supply.

4. In the class discussions of the reports after information on present conditions has been presented, special attention should be given to the things that still need to be done and to the ways in which the members of the class can help to bring these about.

4. It may be possible to make portions of a sanitary survey of a market, a bakery, and a dairy, as suggested in Hoag and Terman's ***Health Work in the Schools***, pp. 244–251.

OUTLINE SUMMARY

Public Water, Milk, and Food Supply

- I. The water supply
    - 1. How water is made impure
    - 2. Purifying water supplies
        - *a.* Treatment with chemicals
        - *b.* Filtration
- II. Milk
    - 1. Use of milk
    - 2. Dangers from impure milk
    - 3. How milk may carry diseases
    - 4. Supervision of milk supplies
    - 5. Certified milk
    - 6. Pasteurized milk
        - *a.* Meaning
        - *b.* Effect on vitamines
        - *c.* Value as a health measure
        - *d.* Extent
        - *e.* Supervision
- III. Foods
    - 1. Diseased foods
    - 2. Adulteration
        - *a.* Mixture
        - *b.* Coloring matter
        - *c.* Preservatives
    - 3. Condemned foods
    - 4. United States Pure Food Law
    - 5. United States Division of Foods
    - 6. City ordinances

QUESTIONS FOR CLASS DISCUSSION

1. How may drinking water become impure?
2. How may it be purified?
3. What results follow from making the water supply pure?
4. How may milk be a means of carrying disease germs?
5. What care is needed to get pure, clean milk?
6. Which is the worst form of food adulteration from the standpoint of health?
7. What has the national government done to help people get pure foods?
8. What is your locality doing to protect its water, milk, and food supply?
9. What more should be done?
10. What is the value of pasteurizing milk?

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Hazen, *Clean Water and How to Get It.* J. Wiley and Sons, New York.

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Water Supplies and Sewerage Systems for Municipalities. Minnesota State Board of Health, Minneapolis.

CHAPTER XXV

HEALTH OFFICERS

1. What are the duties of health officers?

2. What sort of ordinances should a city pass in order to protect the health of its citizens?

When people are living together in communities, it is necessary for all to coöperate in order to look after those matters that affect public health. This work is intrusted to a group of men called the board of health, or to one man called the health officer.

AMOUNT OF MONEY SPENT

Our American towns and cities have given altogether too little attention and money to the very important work of looking after the health of the communities. The work of the boards of health is greatly handicapped by lack of funds. An investigation made of the amount of money spent by various cities in maintaining the work of the boards of health showed that in cities of from thirty thousand to fifty thousand population an average of only twenty-seven cents per capita was spent annually. This sum is not sufficient to provide for the maintenance of an effective board of health; at least twice this amount should be spent. In cities of twenty thousand population and over, one man should be employed to give his entire time to the work. In the case of smaller towns, several communities may unite to employ a man.

POLITICS AND HEALTH

One thing that greatly hinders the work of looking after the public health at the present time is the fact that the appointment of the officers is too often a matter of politics. Men are appointed on account of some political pull, without reference to their fitness for the work. The selection of health officers should be taken out of politics, and only specially qualified men should be appointed. A board of health should have at least one physician connected with it. It is desirable that the health officer should do no practicing.

DUTIES OF BOARD OF HEALTH

The board of health has many important duties to perform. These may be divided into six groups: first, to collect vital statistics; second, to control communicable diseases; third, to reduce infant mortality; fourth, to look after water, milk, and food; fifth, to supervise sanitary conditions in the town; and sixth, to control the fly and the mosquito.

CITY	TOTAL DEATHS	DEATH RATE
Milwaukee	4,716	9.6
Cleveland	9,218	10.2
Newark, N.J.	4,906	11.1
Minneapolis	4,641	11.2
Chicago	32,647	11.2
St. Paul	2,844	11.7
Buffalo	6,913	12.7
Jersey City	3,985	12.8
Philadelphia	25,151	13.0
Columbus	3,513	13.2
Washington	6,496	13.4
St. Louis	10,896	13.5
San Francisco	7,431	13.6
Boston	10,858	14.1
Providence	3,452	14.2
Baltimore	11,176	14.3
Louisville	3,877	15.1
Cincinnati	6,158	15.2
Pittsburgh	9,456	15.2
Atlanta	4,109	18.1
New Orleans	7,531	18.5
Nashville	2,340	19.1
Memphis	3,430	20.0

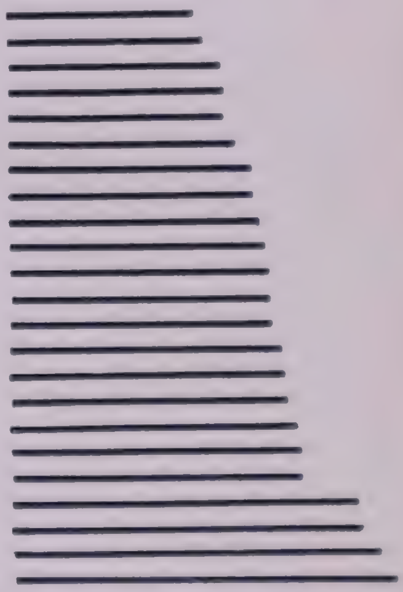


Fig. 161. — Annual death rate per thousand of the population of the chief cities of the United States in 1924

Vital statistics. The vital statistics are the records of all births and deaths. Registration of birth certificates is important because they are frequently used in many practical ways—as evidence to prove the age of heirs, as evidence in the enforcement of laws relating to education and to child labor, as evidence to prove the irresponsibility of young children before the law for certain misdemeanors, as evidence of legal age to marry, as evidence to establish age of voting, as evidence to prove the claims of widows and orphans, and in still other ways.

It is also very important that careful records be kept of every death, of its cause, of the age and sex of the deceased person, and of similar details. These facts may be of great legal and social importance. (1) They will enable public health officials to know the causes of deaths and to act promptly to prevent epidemics. (2) The success or failure of measures attempted in the prevention of disease may be accurately determined. (3) Cities may learn their own health conditions by comparison with the conditions of other cities and thus determine the wise course of public health activity. (4) Certificates of death are constantly required in courts and elsewhere to establish necessary facts. (5) Pensions or life insurance may depend on proper evidence of death.

Control of contagious diseases. One of the duties to which special attention is given is the prevention and control of contagious diseases that may be carried from one person to another, such as diphtheria, smallpox, and tuberculosis. In protecting well people from unconsciously coming into contact with those that have the diseases, very strict measures must be taken, such as isolating the patient and quarantining people who have been exposed. While these restrictions may cause some inconvenience to the people concerned. yet they are necessary in order to protect other people. Signs are placed on houses which contain patients with these diseases, as a warning to other people. After the patient has recovered, sometimes it is necessary to disinfect the house to kill the bacteria that cause the disease.

As a protection against smallpox, sometimes compulsory vaccination may be required; and the board of health may furnish without charge the vaccine for smallpox vaccination, the vaccine for vaccination against typhoid fever, and the antitoxin and toxin-antitoxin for diphtheria.

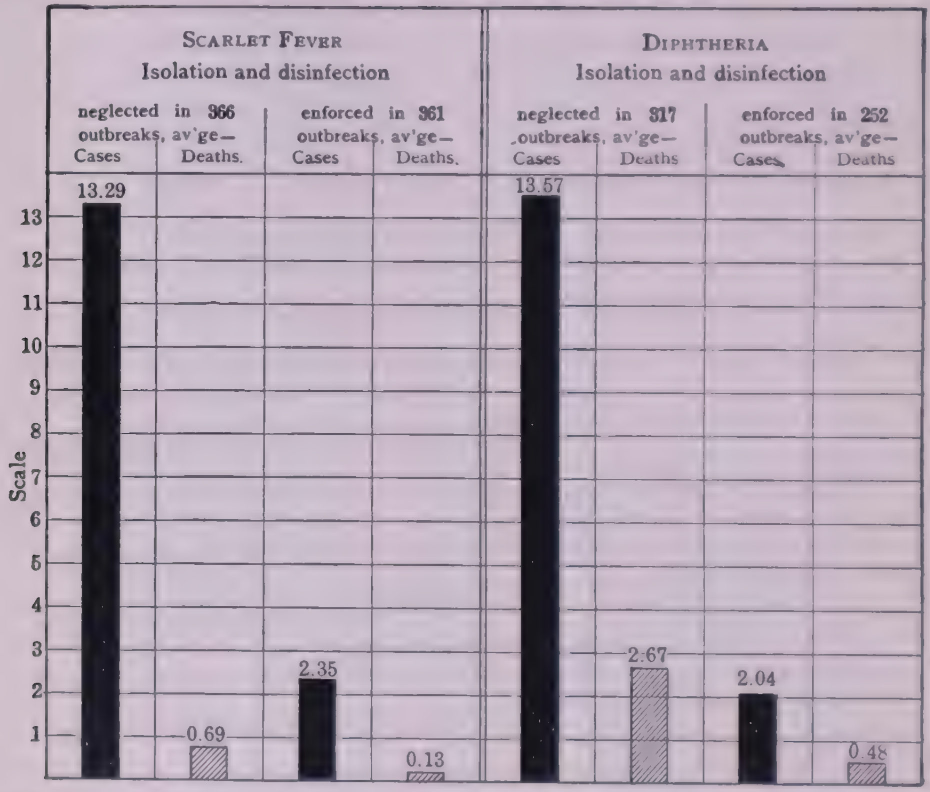


Fig. 162. — Effect of isolation and disinfection on scarlet fever and diphtheria

The board of health may visit the schools to examine the children for evidence of communicable diseases and may take measures to guard against an increased number of cases. School inspection daily or semiweekly by a school nurse is one of the best means of controlling infectious diseases.

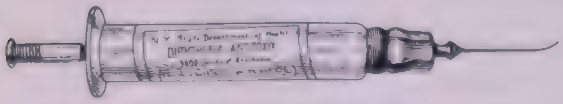


Fig. 163. — Antitoxin for diphtheria

Supervision of milk supply. Many of the deaths among children can be avoided by proper supervision of the milk supply. Statistics show that approximately one fourth of the cases of tuberculosis among children under sixteen years of age are contracted from the milk of tuberculous cows.

Every city should adopt and enforce ordinances regulating the production and handling of milk. Following are some of the regulations that such an ordinance should contain: requiring license to sell milk; testing cattle for tuberculosis in those cases in which the milk is not to be pasteurized; inspection of dairy barns to see that they are kept sanitary; regulations regarding the methods of milking and the subsequent care of the milk; supervision of the distribution of the milk; supervision of the pasteurization plants; and medical examination of all persons engaged in the production or handling of milk, to determine that they are not chronic carriers of infectious diseases.

Supervision of water supply. The public water supply should be guarded with special care. All water supplies from streams or lakes should be subjected to some form of purification, of which chlorination is the most satisfactory, as we learned in Chapter XXIV. If the water comes from underground supplies, the health authorities should see that, in the location, construction, and operation of the wells, proper care is taken to prevent pollution by surface drainage.

Supervision of food supply. The public food supply should also be carefully guarded. The places where the food is cooked—the bakeries—should be carefully inspected. The room where the food is cooked and handled should be kept clean and sanitary. No persons having contagious diseases nor any carriers of such diseases should be allowed to work in these shops. The food, when exposed for sale, should be covered to protect it from dust and flies. The purity of the food should be guaranteed by state and national laws.

Butcher establishments, where animals are killed or where meat is sold, should be carefully watched. Inspectors should make sure that no animal with tuberculosis is sold for meat and that all meat is kept under sanitary conditions.

Fly and mosquito control. Closely allied with the matter of cleanliness is the matter of fly control. The board of health should take measures to see that the breeding places of flies, chief among them the manure piles, are so frequently removed that flies have no opportunity to breed. Ordinances should be enforced relative to the protection of food from flies.

In the southern states, where malaria is found, the board of health should take measures to control the mosquito nuisance. Some of the means by which this may be done have been explained in the previous chapter.

CITY ORDINANCES

As an example of what is being done relating to public health, the following quotations are taken from a list of ordinances passed in a city of fifteen thousand population:

"**Purpose of the Department of Public Health.** *Section 6.* The department of public health shall exercise general supervision over the health of the city. It shall make such investigations and reports, and obey such directions concerning communicable disease, as the State Board of Health of Minnesota may require or give, and under the general supervision of the State Board of Health, it shall cause all laws and regulations relating to the public health to be obeyed and enforced."

"**Duty of the people.** *Section 8.* Every person in the city of —— — shall observe and obey each and every special regulation and every order of the department of public health that is or may be made for carrying into effect any of the provisions of this or any other ordinance of said city relative to the health thereof, or any law of this state or otherwise, whether issued directly by such board, or promulgated by the health commissioner."

"**Duties of the Health Commissioner.** *Section 10.* The health commissioner shall be president of the department and shall have and exercise a general supervision over the sanitary conditions of the city. He shall give the council and the department of public health all such professional advice and information as they may require for the purpose of preserving the public health. He shall investigate the existence of any communicable or pestilential disease and adopt all measures necessary to arrest the progress thereof.

"He shall enforce all laws of the state, and ordinances of the city, in relation to health and sanitary conditions, and shall cause all nuisances as hereinafter defined to be abated or removed. He is hereby empowered and it is hereby made his duty and the duty of the health inspectors to enter any building in said city between sunrise and sunset, for the purpose of ascertaining if such building is in good sanitary condition."

"**Care of food.** *Section 20.* Every person being the owner, agent, lessee, or occupant of any room, stall, or place where any food, meat, fish, or vegetables designated or held for human food shall be stored or kept or shall be held or offered for sale, shall put or keep such room, stall, and place and its appurtenances in a cleanly and wholesome condition, and every person having charge (or interested or engaged, whether as principal or agent) in the care, or in respect to the custody or sale of any food, meat, fish, birds, fowls, or vegetables (designated for human food) shall put and preserve the same in a cleanly and wholesome condition, and shall not allow the same or any part thereof to be poisoned, infected, accessible to flies, or rendered unsafe or unwholesome for human food."

"**Expectorating.** *Section 31.* No person shall spit, or expectorate, or deposit or place any sputum, spittle, saliva, phlegm, mucus, tobacco-juice, cigarette stumps, or quids of tobacco upon the floor or stairway of any part of any public hall or building in the city of ——— or upon the sidewalk of any public street, avenue, or highway in the city of ———, or upon the floors or inside furnishings or equipment, or in any place upon the outside or upon the platform of any street car while the same is in use upon any of the streets or highways in the city of ———, or in any manner defile or pollute the floor, furnishings, equipments, or platform of any street car while in use upon any of the streets or highways of said city."

"**Fines.** *Section 38.* Any person who violates, disobeys, omits, neglects, or refuses to comply with, or who resists, any of the provisions of this ordinance, or who refuses or neglects to obey any of the rules, orders, or sanitary regulations of the department of public health, or who omits, neglects, or refuses to comply with, or who resists any officer of the department of public health, or order or special regulation of the health commissioner, or of said department of public health, shall upon conviction thereof, before any court having competent jurisdiction, be subject to a fine not exceeding one hundred dollars ($100) and costs of prosecution or imprisonment in the city prison or county jail of ——— County for a term not exceeding ninety days."

DUTY OF ALL CITIZENS

One point cannot be too strongly emphasized — namely, that all the people of a town must coöperate with the health officer in order to produce the best results. The citizens must not feel that they have done their entire duty when they have appointed a health officer. He is greatly handicapped unless he has the intelligent and hearty coöperation of the people. Every member of a community should cheerfully obey the health ordinances of the town. Cases of contagious diseases and instances of violation of health ordinances should be reported to the proper authorities. Each person should see that the conditions around his home are healthful and that nothing he does shall be a menace to his neighbors.

COMMUNITY PROJECT 2

Purpose. To study the duties of the local health officer.

Directions. 1. Information should be obtained regarding the local health officers—who they are, how they were appointed, and what they are doing. A copy of the local health ordinances should be secured and discussed in class. The things that the members of the class can do to co-operate with the health officers should be emphasized. Find how much money per capita the town is spending each year to protect the health of the community. Compare with other towns.

2. Make a study of the parks and playgrounds. What bearing do these have on health?

OUTLINE SUMMARY

HEALTH OFFICERS

I. Amount of money spent
II. Politics and health
III. Duties of board of health
    1. Vital statistics
    2. Control of contagious diseases
    3. Supervision of milk supply
    4. Supervision of water supply
    5. Supervision of food supply
    6. Fly and mosquito control
IV. City ordinances
V. Duty of all citizens

QUESTIONS FOR CLASS DISCUSSION

1. What should the people do to help health officers?
2. How do the health officers control contagious diseases?
3. What can they do to keep the milk and food supply pure?
4. What can they do to control the fly and the mosquito?
5. What are the health officers in your town doing?
6. What can you do to help the health officer in his work?

REFERENCE

Coleman, *The People's Health.* The Macmillan Co., New York.

CHAPTER XXVI

SCHOOL HYGIENE

1. What should be done to make the school building a healthful place in which to stay?

2. What sort of physical defects are found among school children?

In recent years people have come to realize that it is most important that the school shall look after the health of the children, because success both in school and outside depends largely on health. Hence we find that special attention is now given to the health of school children. School doctors and nurses are employed to examine children and to remedy defects of eyes, ears, nose, throat, and teeth. In this chapter, reference will be made to two lines of work being carried on in the interest of the children's health: first, the provision of sanitary schoolrooms in which the child works; and second, the medical inspection of children to find and remedy defects and sickness.

LIGHTING THE SCHOOLROOM

In the construction of the schoolhouse, lighting is one of the important things to consider. Plenty of light in a room is necessary for the best health, as well as for the cheerfulness of the room. Wrong methods of lighting seriously injure the eyes. The following points need to be considered: first, the amount of light; second, the direction from which it comes; and third, the height of the window from the floor.

In general the amount of window space should be from one sixth to one fourth of the floor space. During the winter there is less light than in the fall and the spring, and there should be enough windows to provide sufficient light during this season, as well as on cloudy days.

The direction from which the light comes is a second point to consider. The best arrangement is to have the light come from the left. If it comes from the front, it shines directly into the children's eyes and strains them; if it comes from the rear, the shadow of the body is thrown on the desk; if it comes from the right, the shadow of the hand is thrown on the desk.

The bottom of the window should be at such a height that it is above the level of the eyes of the children when they are seated. This should be from three and one-half to four feet. If it is lower than this it strains the eyes more, because the light shines directly into them. The top of the window should reach up well toward the ceiling, as the light from high up is better distributed throughout the room.

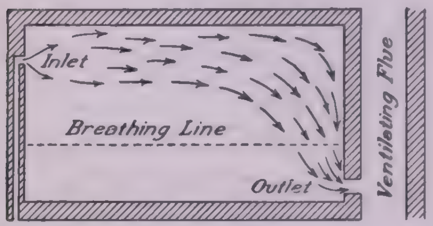
HEATING AND VENTILATING THE BUILDING

The general principles involved in heating and ventilating the school building are the same as those involved in the home, which were discussed in Chapters II and III. But in the schoolroom more attention should be given to ventilation than is given ordinarily in the home, because a larger number of persons are gathered in one room.

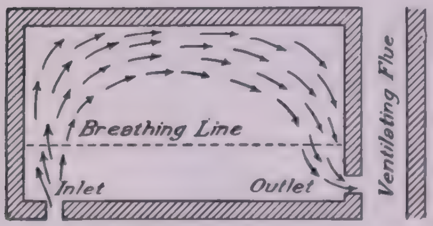
Essentials of ventilation. As we have seen in Chapter III, good ventilation requires attention to the following matters: a constant supply of fresh air, a motion of air, the right degree of temperature, and the right percentage of humidity.

Fresh air and motion. To keep a constant supply of fresh air requires two openings in a room — namely, an inlet where the fresh air enters and an outlet where the used air is removed. Experiments which have been carried on show that the best place for the inlet is about eight or nine feet from the floor, and that the best place for the outlet is within a foot of the floor and on the same side of the room as the inlet. In securing this supply of fresh air, a motion of air is provided for at the same time.

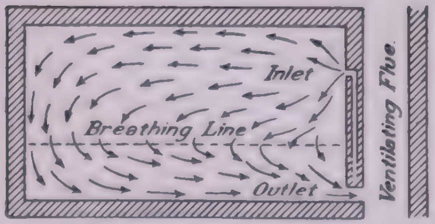
Gravity system. Various methods are used to produce this circulation of air. In the gravity system the motion is brought about through a difference in the weight of the air due to a difference in temperature. The foul-air duct is connected with the chimney. Since the air here is much warmer than the air outdoors, it rises; while the cold air is taken in at the basement and, after being heated, is led into the various rooms. This may work fairly well in cold climates during the winter if the air outdoors is much colder than that in the schoolroom. But in the fall and the spring, when the difference in temperature is small, the system is not satisfactory.



Air admitted on side.
Discharged near bottom.



Air admitted at bottom
Discharged near bottom.



Inlet near top.
Discharge near bottom

Fig. 164. — Inlets and outlets

Fans. In order to obtain the best circulation, fans are generally used. Two systems are employed, the pressure and the exhaust. In the pressure system, the air is forced into the room by means of a fan located in the basement. In the exhaust system, the air is drawn out of the room by means of a fan which rotates in such a way as to suck the air out. If only one of these systems is used, it should be the pressure system, as that is generally found to be better. Sometimes both systems are used.

Sometimes two methods of heating are employed. To provide ventilation, fresh air is forced into the rooms at about the desired temperature; and the exact temperature is controlled by means of steam or hot-water radiators placed in each room. This combination makes a very satisfactory heating and ventilating system when properly cared for.

Window ventilation. Experiments have shown that ventilation by windows may be very satisfactory when properly operated. One series of experiments carried out on 5,500 children in a New York school showed that window ventilation when compared with fan ventilation creates a more comfortable atmosphere, is attended by less respiratory disease, and is more economical to install and operate.

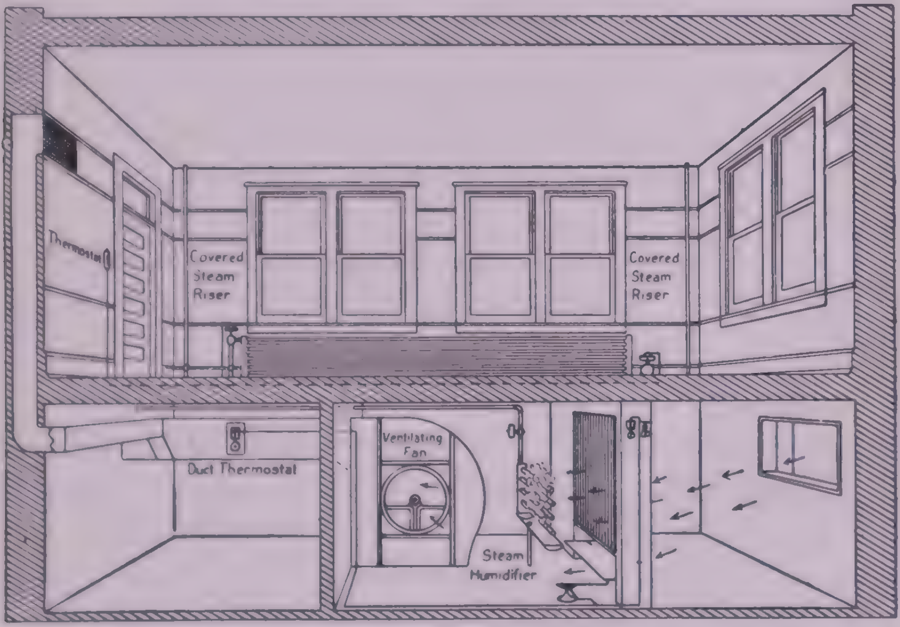


Fig. 165. — School ventilating system that supplies warm air of correct humidity

Temperature. The best temperature varies in accordance with a number of factors, such as the clothing worn by the children and the kind of school work being done, whether active or passive. It depends also on the humidity. In the dry atmosphere found in most school buildings the proper temperature is about sixty-eight degrees. If moisture is added to secure the proper per cent of humidity, a temperature of sixty-five is sufficient. The temperature may be kept even by means of a thermostat. If the temperature runs too high, the thermostat shuts out the warm air and opens the cold-air damper wider; if the temperature is too low, the thermostat causes a reversal of this action. Sometimes the thermostat shuts and opens the valves controlling the steam entering the radiators.

Humidity in schoolrooms. During the colder portions of the year the humidity of our schoolrooms tends to be too low. One great defect in many ventilating systems is that they do not have arrangements to increase the humidity. The average humidity of schoolrooms in winter ranges from 20 to 30 per cent. This is a very dry air and is harmful to the health of those living in it, as explained in Chapter III. Experiments which were carried on at Yale University showed that when the air was kept at the proper humidity the students were able to do better mental work and were freer from colds than when the humidity was low. Experiments show that the proper percentage of humidity for the schoolroom is about fifty.

How humidity is determined. One may naturally ask at this point, "How can one tell what the percentage of humidity in a room is?" This is determined by an instrument called a psychrometer, which consists of two thermometers, one of which has a piece of wet cloth fastened over the bulb. We have often noticed that when our hands are wet on a cold day, they are colder than when dry. This difference is due to evaporation of the water, which makes things colder around it; that is, heat is necessary to change water to vapor, and this heat is taken from the surrounding bodies. On hot days sidewalks are often sprayed with water to cool off the surrounding air.

In a similar way, the water in the cloth on the bulb of the thermometer evaporates and lowers the temperature of the thermometer, so that if the two thermometers are compared, the reading of the one with the wet cloth will be found the lower. The difference between these two thermometers varies from day to day. The amount of water that evaporates and hence the lowering of the temperature depend on the amount of moisture in the air. If the air is saturated, no water will evaporate, and hence there will be no difference in the readings of the two thermometers. On the other hand, if the air is very dry a large amount of water will evaporate, and the reading of the wet bulb will be much lower than that of the dry bulb. In general, then, a small difference between the two bulbs means a high percentage of humidity, while a large difference means a low percentage of humidity. Tables have been worked out by which, if one reads the two thermometers, it is possible to find at once the percentage of humidity. (See page 569.)

In order to get an accurate reading, the thermometers should be fanned for a few minutes; or, even better, they may be attached to a board which can be rotated in the hand by means of a handle. Such an instrument is called a sling psychrometer.

Humidifiers. While many of the older buildings have no arrangement for adding water to the air, a number of satisfactory systems are being introduced into the better and newer buildings. In one system, steam is allowed to escape through small holes in pipes placed in the cold-air pipe. Or, instead of steam, water in the form of a spray may be forced in through nozzles.

Fig. 166. — Paper towels

A sanitary substitute for the dangerous public towel.

In accordance with another plan large pans of steaming hot water are placed in the cold-air duct. In still another plan, a rotating cylinder is placed in the fresh-air pipe. This is covered with a coarse-meshed cloth; and as the cylinder revolves, the lower edge passes through a trough filled with water. Thus the cloth is kept moist and dripping all the time. As thermostats are used to regulate the temperature, so humidostats may be used to control the humidity.

DEMONSTRATION 54

Purpose. To see if the ventilating system of your school furnishes the essentials of good ventilation.

Apparatus. Touch-paper; down; two thermometers.

Directions. 1. To find the amount of air entering the room: Throw a tuft of down in front of the air inlet and estimate how far it travels in a second. Try several times and take the average. Measure the dimensions of the air inlet. Find its area. Multiply this by the velocity of air just found, so as to compute the cubic feet of air that enter the room each second; then find the number for each minute. Multiply the number of pupils in the class by thirty, which has been set as the standard number of cubic feet that should be furnished each pupil per minute. How does the amount of air entering the room compare with this product?

2. Air currents. Light a piece of touch-paper and hold in various parts of the room to determine the direction and strength of the air currents. On the board make a diagram of the room and indicate the direction of the currents by means of arrows.

3. Temperature. Place a thermometer in different parts of the room and find the temperature. Try on several days. Compare with the standard of 68°.

4. Humidity. Test the humidity as explained in Demonstration 11, page 48. Compare with the standard of 50° to 60°. Find the humidity outdoors.

5. Which of the four essentials of ventilation are provided in the schoolroom? Which are lacking? How may the deficiency be remedied?

SANITARY DRINKING FOUNTAINS

The common drinking cup should be abolished from every school. It is one means by which such diseases as tuberculosis, diphtheria, mumps, pneumonia, and other common infectious diseases are transmitted. Even well children may carry disease germs in their mouths; hence the common drinking cup is a source of danger wherever found. An individual drinking cup may be made out of a piece of clean paper, as shown in figure 143. With the many types of drinking fountains now available, there is no excuse for allowing the public cup to be used any longer. Even where running water is not available, water jars to which sanitary drinking fountains are attached may be obtained.

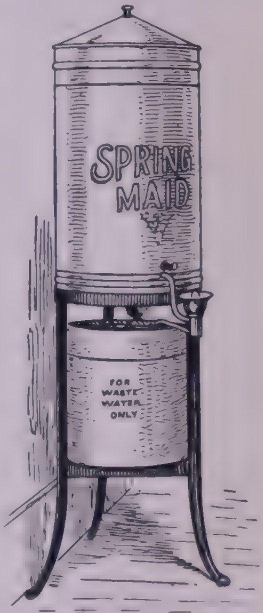


Fig. 167. — Fountain faucet

PLAYGROUNDS

A properly equipped school needs a large playground. One great defect of our schools, in the country as well as in the city, is the small size of the playground. Whenever a new building is being planned, provision should be made for large playgrounds, with room for baseball grounds, tennis courts, and open spaces for other games. Play is an essential part of a child's life. It not only furnishes the physical exercise that the growing child needs, but it also has a distinct educational value in itself.

OPEN-AIR SCHOOLS

In recent years open-air schools have been established for tuberculous and sickly children unable to attend regular schools. Sometimes open-air schools are entirely in the open, sometimes they are provided with roofs, and sometimes an ordinary room is changed into an open-air school by hinging the windows at the top and opening them to their fullest capacity. For the colder seasons the children are provided with special clothing to keep them warm. These schools have proved almost universally successful in that the children have made great gains physically and are able to do better work in their school subjects. If these open-air schools are good for weak and sickly children, we are naturally led to inquire why they would not be good for ordinary children also.

PHYSICAL DEFECTS IN SCHOOL CHILDREN

When the conditions under which children study have been made healthful, the next step in looking after the health of children is to examine the children themselves to see whether they have any physical defects that can be remedied. In many sections of the country, children have been examined, and the results show that more than half of all children have some defects of the ear, eye, teeth, throat, or nose. In many cases neither the children nor their parents had known that such defects existed. When these defects are discovered, they can generally be remedied; and thus the children are made happier and better able to do their work. The results of the examinations of hundreds of thousands of children in all parts of the United States are shown in the following table in the first two columns. The last column is obtained by estimate through multiplying the number of school children in the United States (about twenty-five million) by the percentages obtained from those children who have been examined.

TABLE SHOWING DEFECTS OF CHILDREN

KIND OF DEFECT	PER CENT AFFECTED	TOTAL NUMBER AFFECTED IN U. S.
Defects of ear	2	500,000
Defects of nose and throat	20	5,000,000
Defects of eye	25	6,250,000
Defects of teeth	65	16,250,000

It is found that only about one third of the children are free from defects, about one third have defects of teeth alone, and the remaining third have defects of the teeth and, in addition, at least one other defect.

Defective teeth. The most common of all defects are those of the teeth. From two thirds to three fourths of all children are found to have defective teeth. These include every stage from a tooth with only a small decaying spot to one that is almost entirely decayed. Of all teeth examined, about one fifth are defective.

How defective teeth injure health. Defective teeth may prove injurious to health in three ways: First, the power of mastication of food is decreased; second, the pus from the decaying teeth when absorbed into the blood or taken into the stomach has an injurious effect; and third, decaying teeth may be the breeding place of bacteria that cause disease, such as rheumatism and heart disease. Some very remarkable cures of rheumatism have been effected by the extraction of abscessed teeth.

Purposes of mastication. Mastication serves many useful purposes, as we have already learned in Chapter VII. These uses may be summarized briefly as follows: First, mastication grinds the food into a fine mass and thus prepares it for the process of digestion which takes place in the stomach and intestines; second, the thorough mixture with the saliva begins the act of digestion in the starch; third, thorough mastication better enables one to determine how much food and what kinds he should eat; fourth, it helps the normal growth of the teeth and jaw; fifth, thorough mastication helps to clean the teeth. When the teeth are defective, mastication is done less thoroughly, and hence these purposes are fulfilled less successfully.

Dental clinics. Dental clinics are now being introduced into many of our cities. The teeth of the children are examined and treated by dentists hired by the school authorities. As teachers are hired to teach children how to read, so dentists are hired to look after the children's teeth. These clinics are very common in Europe and are rapidly increasing in number in this country. One agricultural paper suggests that a new "R.F.D." be established — "rural free dentistry."

Defects of the eye. About one quarter of all children are suffering from defects of the eye. In order to understand what these defects are, we shall need to examine the eye to see how it is constructed and how it works. We may compare it with a camera. The eyeball corresponds to the camera box; the lens in the eye, to the camera lens; the iris and the pupil of the eye, to the diaphragm of the camera; and the retina which lines the eye, to the sensitive surface on the film or glass on which the picture is taken.

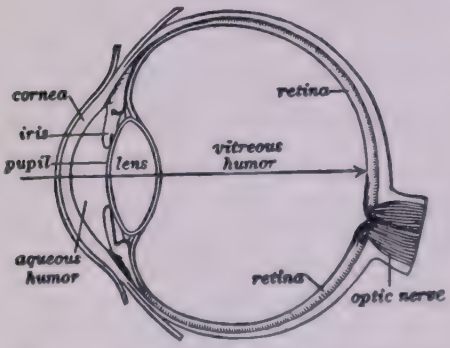


Fig. 168. — Section of the human eye

In the average good eye, rays of light pass through the eye lens and are focused on the retina, where an inverted image is formed in each eye. This image causes impulses to pass along nerves to the brain, which gives us the sensation of a single image right side up. The brain inverts the images and causes us to see one image instead of two images.

Kinds of defects. There are three common defects of the eye: nearsightedness, farsightedness, and astigmatism. In nearsightedness, the rays of light come to a focus before they reach the retina, and hence the image is blurred. In farsightedness, the rays would focus behind the retina if they could pass through this. In astigmatism, the curvature of the lens is not the same in all directions; and while a vertical line may be clearly focused, a horizontal line is blurred. The eye attempts to remedy these defects by accommodation; but this involves a straining of the eye muscles, especially in farsightedness and astigmatism, and may result in eye ache and headache.

Testing the eyes. Nearsightedness may be easily detected by means of the Snellen card, which is a chart with a series of letters of different sizes, showing the distance at which each size of the letters can be seen by the average eye. Each eye is tested separately; and if a person is nearsighted, this defect is shown by his inability to read the letters at the standard distance. To test for astigmatism, a card is used containing a number of lines extending in different directions from a common center like spokes of a wheel. (See figure 169.) Astigmatism is shown if certain lines appear blacker than others.

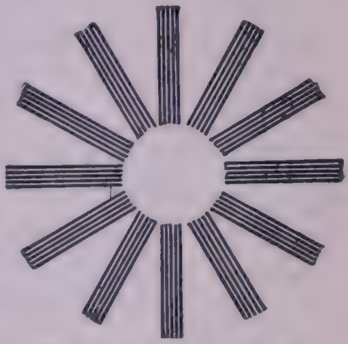


Fig. 169. — Lines to test astigmatism

Remedies. The remedy for nearsightedness is a concave lens, which helps to throw the focus further back on the retina. The remedy for farsightedness is a convex lens, which brings the light to a focus more quickly. The remedy for astigmatism is a lens with unequal curvature in different directions to offset the unequal curvature of the eye lens.

The science of the oculist has developed so far that most of these common defects can be easily remedied by the use of spectacles. In the case of a very nearsighted person, a pair of spectacles brings about such a remarkable change, in enabling him to see things he has never seen before, that all life takes on a new aspect. Glasses should be fitted only by a competent oculist.

School work requires so much use of the eyes that care should be taken to reduce as much as possible the strain on the eyes. There should be the proper amount of light in the schoolroom. The books used should be printed on good paper, and the type should be plain and large; for growing children, type should be larger than that required for adults. An excessive amount of written and home work should be avoided.

DEMONSTRATION 55

Purpose. To illustrate the working of the eye.

Apparatus. Reading lens; cardboard; candle; concave lens; convex lens.

Directions. 1. To show how the image is formed: Adjust the reading glass and the cardboard in line with the window till images appear distinct on the cardboard. To what in the eye do the cardboard and the lens correspond? How does the image differ from the object?

2. To illustrate the conditions for nearsightedness: Set a lighted candle on a table and place a piece of white cardboard about two feet away. Put the reading glass between the two in such a way that an image of the candle appears on the cardboard. To show nearsightedness, move the cardboard farther away from the lens till the image is blurred. To show the remedy, put a concave lens in front of the reading glass.

3. To illustrate the conditions for farsightedness: Adjust the cardboard, candle, and reading glass as in the previous experiment, till the image is clear. Then move the cardboard nearer the lens till the image is blurred. This illustrates farsightedness. To show the remedy, place a convex lens in front of the reading glass.

Defects of nose and throat. Defects of the nose and throat are quite common; about two million children in the United States are suffering from obstructed breathing. The most common defects are adenoids and enlarged tonsils; these tend to obstruct the nasal passages and to cause mouth breathing. This is not as healthful as nose breathing, because when air passes through the nose, it is filtered of dust and bacteria, warmed, and humidified. In some cases these obstructions interfere seriously with the mental development of the child. Inflammation of the nose and throat often spreads to the ear through a tube connecting the two and thus causes deafness. In many cases the difficulty may be remedied by a simple operation in which the tonsils, or adenoids, or both are removed.

Defects of the ear. A small percentage of children have defects of the ear. Since the chief cause of these defects is a diseased condition of the throat and nose, it is important to give proper care to these troubles before they spread to the ear. Two other causes of defective hearing are infectious diseases and stoppage of the ear canal. The diseases that are most apt to affect the ear are scarlet fever, measles, and diphtheria.

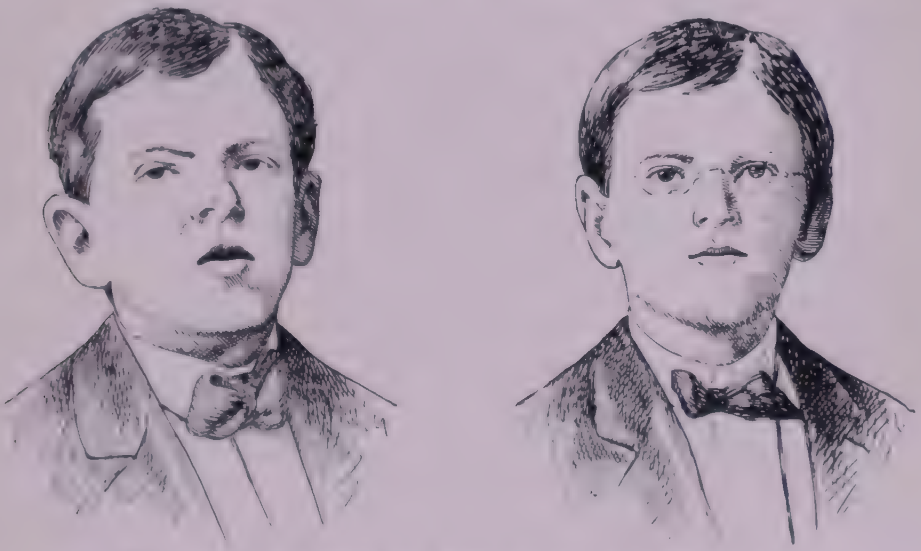


Fig. 170. — Before and after removal of adenoids

Accumulations of wax sometimes cause deafness. However, if taken in time, the wax may be easily removed by a doctor. It is dangerous to run hairpins and other objects into the ear in order to remove wax.

The ears may be tested by means of a watch. The person's eyes should first be covered, and then each ear tested separately. The watch is held at varying distances, and the greatest distance at which it can be heard is ascertained. Meanwhile one of the ears should be covered. The important point is to compare the distance at which a child hears the watch with the average distance at which it can be heard by a number of persons of normal hearing.

MEDICAL INSPECTION OF SCHOOL CHILDREN

The state requires the child to attend school until a certain age is reached. At school the child is exposed to some dangers that he would not encounter at home. Since the law compels a child to attend school, the law should protect his health while there. Medical inspection of schools should naturally follow compulsory attendance.

Medical inspection serves two large purposes: first, to detect infectious diseases; and second, to detect and remedy any defects of eye, ear, etc., that interfere with the child's development. The school is the best place to detect and control infectious diseases in order that the other children and the entire community may be protected.

In the larger cities a corps of competent doctors and nurses should be hired to carry on this work. The chief work of the doctors is to discover the defects; the nurse follows up each case and visits the home, trying to see that the parents give the child the needed treatment. In some cities clinics are being established where children are treated for their defects if the parents are too poor or too careless to have it done. It seems natural and logical not only to find out the defects but also to remedy them.

In some smaller towns which cannot afford to hire both a doctor and a nurse, it is found that a nurse alone can do very effective work; and in many instances a town or a small city employs a school nurse, who is the most important single factor in the work of medical inspection because she is constantly on duty and visits the homes.

Advantages of medical inspection. Medical inspection is found to have the following advantages: First, it is a means of preventing the spread of infectious diseases; second, school work proceeds more successfully because there is a saving of time that might otherwise be lost on account of sickness, and the children are able to do better school work because they are in better health; third, it makes the child happier and gives him a better chance in life; fourth, it is a means of educating the public in the matter of health.

Work of nurse and doctor. In working out a system of medical inspection, the following things are done by the doctor or nurse: First, a thorough examination is made of every child when he enters school; second, a daily examination is made of all children reported ill by the teacher; third, after a child has been out of school, he is examined when he returns; fourth, the nurse makes occasional examinations of the eyes, ears, teeth, nose, and throat; fifth, frequent inspections are made to detect contagious diseases, and cases of these are referred to the board of health; sixth, the school nurse looks after the minor kinds of sickness and gives instructions in practical hygiene to the children; seventh, the school nurse follows up the cases when defects are reported, by visiting the homes and encouraging the parents to have the children treated; eighth, in cases where the parents cannot or do not see that the child receives the necessary treatment, the school may have it done.

School Project 4

Purpose. To make a sanitary survey of the school.

Directions. Procure a copy of Hoag and Terman's *Health Work in the Schools*, published by Houghton Mifflin Co., Boston. Make a survey of your school, following the outline given on pages 246–248. As a result of this survey, would you say that the sanitary conditions in your school are satisfactory? If not, what is lacking? What can be done to remedy these defects? See if you can ascertain by inquiry how the conditions in your school compare with the conditions in other schools.

OUTLINE SUMMARY

School Hygiene

- I. Lighting the schoolroom
- II. Heating and ventilating the building
  - 1. Essentials of ventilation
    - *a.* Fresh air and motion
      - (1) Gravity system
      - (2) Fans
      - (3) Window ventilation
    - *b.* Temperature
    - *c.* Humidity
      - (1) How determined
      - (2) Humidifiers
- III. Sanitary drinking fountains
- IV. Playgrounds
- V. Open-air schools
- VI. Physical defects of school children
  - 1. Defective teeth
    - *a.* How they affect health
    - *b.* Purposes of mastication
    - *c.* Dental clinics
  - 2. Defects of the eye
    - *a.* Kinds of defects
    - *b.* Testing the eyes
    - *c.* Remedies
  - 3. Defects of nose and throat
  - 4. Defects of the ear
- VII. Medical inspection of school children
  - 1. Advantages of inspection
  - 2. Work of nurse and doctor

QUESTIONS FOR CLASS DISCUSSION

1. What are the proper methods of lighting the schoolroom?

2. What are the best ways of heating and ventilating the schoolroom?

3. Does the system used in your schoolroom furnish the essentials of ventilation?

4. In what ways may a circulation of air be maintained in the schoolroom?

5. How may the percentage of humidity of a room be determined?

6. How may the proper amount of moisture be introduced into the room?

7. Why should the public drinking cup be abolished?

8. What is the purpose of medical inspection of schools?

9. Why is medical inspection of schools extremely desirable and almost necessary?

10. Why is the school nurse a very important factor in a system of medical inspection?

11. What effects have defective teeth on health?

12. How may some defects of the eye be remedied?

13. What harm is done to health by adenoids and enlarged tonsils?

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Ayres, May, and Others, *Healthful Schools.* Houghton Mifflin Co., Boston.

Dresslar, *School Hygiene.* The Macmillan Co., New York.

CHAPTER XXVII

MOVING PICTURES

How moving pictures are made and how they are thrown on the screen.

PLACE OF MOVIES IN MODERN LIFE

The moving picture is another recent application of science which has had a rapid development and has come to be used by millions of people. Moving pictures are now found in all parts of the country, and almost every town has one or more moving-picture theaters. These have become in a very real way the people's theaters. The movies are now the favorite recreation of the American people. In 1924 there were about eighteen thousand moving-picture theaters in the United States. It has been estimated that the average weekly attendance at these theaters is fifty millions. The total of all the films shown daily in these theaters would be sufficient to reach around the earth at its largest diameter. The film manufacturers turn out 150,000 miles of film in a year.

FEATURES SHOWN AT THE MOVIES

In the early days of the movies, people attended simply out of curiosity, to see any demonstration of what the movies could show, such as a horse race or a fire. People soon tired of this sort of thing, however, and the next step was the introduction of a story told in pictures. At first these stories were quite simple and short; but gradually the story was improved in quality, and eventually it was lengthened to make the five or six reel feature-play, known as the photoplay, which is now the main attraction. At first the actors were advertised as the leading feature, and certain stars became famous the world over. Later more attention was paid to the story and its author; and today the author and the actor both play important parts in drawing the crowd.

The photoplay. A photoplay in its preparation goes through five or six well marked stages. First, and the foundation of all that follows, is the story itself. This may be an original story written specially for the screen, or it may be an adaptation of a magazine story, a novel, or a stage play. This story is first written as a synopsis, which is much like the form in which stories appear in magazines, only it is much shorter.

The next step is the preparation of a continuity. For this work a special staff of trained writers is kept by the various studios. This is very different from the synopsis. It would make very dull reading if a person should start to read it as a story. In the continuity the story is written out in scenes in great detail just as it is to be acted while being photographed. Following is a sample of one scene taken from "The Judgment of the Storm."

> 309. Close-up on Three
>
> John facing background turns slowly toward the officer and Martin; smiles unbelievingly as he speaks title.
>
> (Insert)
>
> "Why, you're crazy! That's my mother."

After the continuity is written, the director takes charge and assumes the responsibility of actually putting on the play. The next step is to select the actors who are to play the various parts. For the staging of the plays, huge, specially lighted studios have been built, most of which are situated in California. After the details are all planned and the parts rehearsed, then the camera is brought on; and the real play is staged while the pictures are being taken. Many times the various scenes are played over and over again before the director is satisfied with the results. Frequently these scenes are not taken in the order in which they appear in the picture. Oftentimes all the scenes that occur in one place are taken, one after another, and then later the film is cut and matched according to the order of the story.

After the films have been developed and printed comes the task of making the titles — the written part of the play, including spoken words and brief explanations to make the pictures plain.

Finally comes the editing of the film. An average picture as shown on the screen has about a mile of film. In taking the pictures in the first place, much more than this was photographed — perhaps two or three or even more miles. All this must be sorted over, part discarded and part selected, till a film of the desired length is obtained. The reel of about a thousand feet of film is the unit of measuring plays, and the average feature-play contains five or six reels.

Educational films. While the majority of the films shown at the movies are for the purpose of entertainment, films are occasionally shown that have an educational purpose, such as films showing various phases of science.

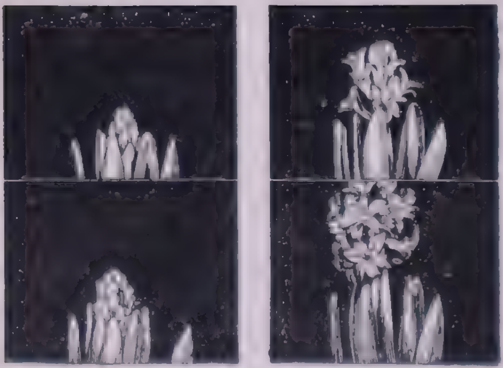

Fig. 171. — Birth of a flower

Film for movies, showing growth on 2d, 4th, 6th, and 8th days.

Science and moving pictures. Moving pictures have been used to illustrate many interesting things in nature. In order to show the opening of a flower or the entire growth of a plant from seed to blossom, the camera is focused on the object and a picture is taken automatically every half hour or so during the entire period. These pictures are then shown rapidly on the screen, and happenings that really occupied several weeks or months in nature are shown here in a few minutes. In a similar way, films show the development of caterpillars into butterflies, the development of the house fly, the development of the chick in the egg, and the breaking of the egg. A number of moving pictures of birds feeding their young have been made with the camera operated from a distance by electric motor drive.

With the aid of the microscope, moving pictures have been taken of such small objects as bacteria. In connection with the use of X-rays, pictures have been taken showing the motions of the stomach of a frog during the process of digestion.

Moving pictures in the schoolroom. There is a great opportunity for the use of moving pictures in schoolrooms. Already some schools are being equipped with moving-picture outfits. Geography can be made much more real by means of moving pictures. Great mountains, lakes, and rivers are easily shown, as well as the activities of people in various countries, together with their costumes and their habits. In fact there seems almost no end to the possibilities of moving pictures in geography. In science many things can be shown, as suggested above. There are also great possibilities in connection with literature.

Animated newspaper. One of the standard developments in moving pictures is the animated newspaper. This is edited and planned in a way similar to the ordinary paper. Operators are kept in various sections of the country to obtain pictures of events of special interest in these different localities. The films are sent to the main offices of the paper, where positive films are quickly made ready to send out to the subscribers — in this case, the picture houses. This work is done so rapidly that if the original film is received by ten o'clock at night, the positive films are ready to send out by two o'clock the next morning. These

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films may then be taken out by the early morning trains. These news films have regular subscribers among the theater men, to whom the reels are sent regularly. Some news films are published once a week, some twice a week.

Animated cartoons. Another development of the movies that has now become well established is the animated cartoon.

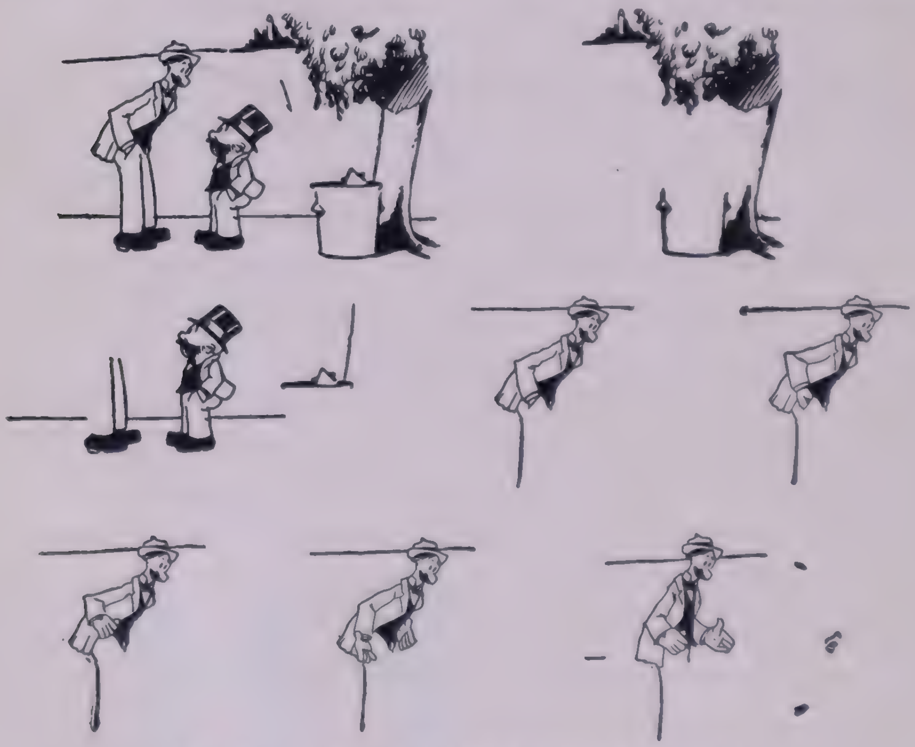

Fig. 172. — Drawings for animated cartoons

These are the drawings required to show the whole process of withdrawing Mutt's hand and closing his eye.

There is almost no limit to the ideas that may be worked out in this way. These cartoons are made by taking photographs of a series of drawings. One drawing is placed before a camera and a picture taken, then another drawing and another picture taken, and so on till pictures have been taken of all the drawings. The pictures made from these exposures are shown rapidly on the screen, so that a series of drawings which required five weeks' work or more on the part of the artist is seen by the audience in eight minutes. In order to procure a half reel (about five hundred feet) of animated cartoons, about eight thousand drawings must be made. Some idea of the number of drawings required may be gained from the fact that in the Mutt and Jeff pictures (see figure 172) it takes four drawings to show Mutt withdrawing his hand from his pocket and three drawings to show him winking his eye. In order to make the Mutt and Jeff drawings, sixty assistants were employed to help the head artist, who had general charge of the work.

HISTORY OF MOVING PICTURES

Early experiments. Let us first notice some of the early attempts to make moving pictures, and then notice some of the progress that has been made in recent years. In 1872 Edward Muybridge, a resident of San Francisco, conceived a plan for taking a series of pictures in rapid succession. His plan required the use of a large number of cameras set up side by side. About ten years later, Dr. Marey in France made improvements on the plan of Mr. Muybridge. He devised a plan according to which all the pictures were taken by one camera, the operator turning a handle. This was a great step forward, because it reduced the expense and it took all the pictures from one position. This may be called the real forerunner of the

Fig. 173. — Muybridge, sometimes called the father of moving pictures

modern moving-picture camera. In 1886 Dr. Marey gave a special exhibition of the results that he had obtained.

Developments in photography. Before any marked progress could be made in the development of moving pictures, two improvements in photography were necessary. These were: first, the substitution of films for glass plates; and second, the making of a more sensitive surface for coating the plate, so that the pictures could be taken with a very short exposure.

Celluloid film. Mr. Eastman, of Rochester, New York, succeeded in developing a sensitive film to take the place of glass plates. Experiments were made with many substances in the attempt to find one that was transparent, that could be made in thin sheets, and that was flexible and strong enough to be wound around a roller. After many failures, Mr. Eastman made a celluloid film that met these requirements. The sheets of celluloid are coated with sensitive chemicals for making the negatives. In 1889 the first long strips of film suitable for moving-picture work appeared.

Edison's kinetoscope. While Mr. Eastman had been working to perfect a film, Thomas Edison had been working on a mechanism to show the pictures to the public. After the film had been perfected by Mr. Eastman, it was used by Mr. Edison in the kinetoscope, the first moving-picture machine. This was on exhibition at the World's Fair at Chicago in 1893 and attracted a great deal of attention. It was a boxlike structure containing a slot. When a nickel was dropped into the slot and the eye applied to the opening, pictures passed before the eye with such rapidity that they seemed to be alive. Within the box was a long film of pictures revolving around a series of spools. Just below the peephole was a revolving shutter. A motor caused the film to move across the field of vision and caused the shutter to revolve in such a way that a series of pictures was presented rapidly to the eye.

Although this machine attracted much attention, it was looked upon at first as only a toy; its commercial possibilities were not realized. The circumstances remind one very strongly of the reception given the telephone at the Centennial Exhibition at Philadelphia in 1876.

Fig. 174. — Edison, inventor of the kinetoscope and the phonograph

Paul's animatograph. The first attempts to project moving pictures on a screen so that they might be seen by many people at the same time were made in England by Robert W. Paul, who called his machine the animatograph. He invented a device by which the film was brought into a fixed position for a very brief space of time, and thus enough light was allowed to pass through to make the images distinct. This was first successfully operated in London in 1895. In the following year there was given a public demonstration, which proved highly successful. This animatograph was introduced at the Olympia, where it proved the most attractive feature. The Olympia, then, was the first moving-picture theater; and in Great Britain, Robert Paul is called the father of the moving pictures.

Lumière's cinematograph. At the same time that Robert Paul was experimenting with his machine in England, MM. Lumière and Sons were working on the same problem in France. They perfected a camera for taking the pictures and a projector for throwing them on the screen. They called their machine the cinematograph. This proved successful and was used in France about the time of the first use of the Paul machine in England. It was the French cinematograph which was introduced into America and which laid the foundation for the development of moving pictures in this country. Although it was the invention of an American, Thomas Edison, that made the moving pictures possible, they were developed in both England and France before they were developed in this country. The first moving pictures to appear in America were exhibited in 1896 at the Eden Musée in New York.

Having noticed briefly the history of moving pictures, we may consider how the pictures are produced and how they are thrown upon the screen.

THE MECHANICS OF MOVING PICTURES

Making the film. The Eastman Kodak Company alone manufactures about one hundred miles of film daily. In the manufacture of the film, such vegetable materials as flax and cotton waste are used. These are treated with acids which change the materials to guncotton. This is then dissolved in wood alcohol, and the liquid is spread out in a thin coating over smooth surfaces, where it is allowed to dry. This forms the celluloid base of the film, which is then coated with the sensitive emulsion. The film sheet is cut up into strips one and three-eighths inches wide, which is the standard width for movie cameras and projectors. The materials of which the films were formerly made were highly inflammable, and their use was attended with danger of fire. A kind of material has now been made, however, which is practically fireproof.

In order to have the film move steadily in the camera and the projector, holes are made along either side of the film by means of machines. The standard is sixty-four holes per foot. The success of the picture depends to a great extent upon the care with which these holes are made.

Moving-picture camera. The moving-picture camera consists of three parts: the camera proper, a box for the unexposed film, and a box for the exposed film. By turning a handle, the film is unwound and brought behind the shutter and in line with the lens; then, as the shutter revolves and brings an open sector before the film, the latter is exposed, after which it is wound up in the other box. These boxes can easily be detached from the camera; and after one film has been exposed, the box can be removed and another with unexposed film put in its place. The motion is given to the film by turning a crank attached to the side of the camera. This is so constructed that the film moves by jerks, so that the exposed section of the film is quiet for a fraction of a second while the picture is being taken. The crank, which may be operated either by hand or by a motor, is turned at such a speed as to make usually about sixteen exposures a second.

When the end of a series of exposures is reached, the operator pushes a film-punch projecting from the camera, which makes punch-marks on the film. The number of feet of film that has been used is indicated automatically on a dial, so that the operator may know when to change the film. The length of these films may vary from one hundred to four hundred feet, depending on the size of the camera.

When an object is to be taken which is moving both horizontally and vertically, like a flying machine, a special kind of tripod is used. This has two sets of gears and wheels, one of which moves the camera in a horizontal plane, while the other moves it up and down. Two men are needed to operate this machine — one to turn the handle for taking the pictures, and the other to move the camera so that the object to be photographed is kept in the center of the field of vision.

Preparing the film. Special means must be employed for handling long films in development. The films are wound around long wooden frames or reels. The principle involved is the same as that described in Chapter XI. The films for one subject are often developed in several parts and then are fastened together by means of a transparent cement. There is often great waste in the film, sometimes as much as 20 per cent being thrown away on account of imperfections in the filming process.

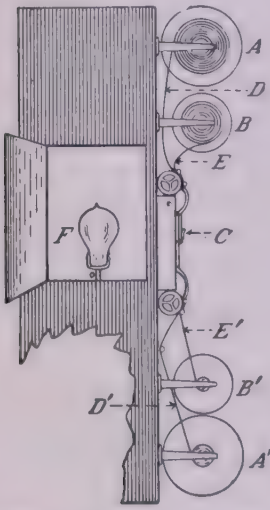

Fig. 175. — A motion-picture printing machine

A–A′ — Rollers for negative film.
B–B′ — Rollers for positive film.
C — Film gate, where positive is held over negative for printing.
E — Unexposed positive film.
E′ — Exposed or printed positive film.
F — Light which, shining through film gate, imprints image of negative on positive.

In order to make a positive that can be used in the projecting apparatus, another strip of film similar to the first one, except that it is less sensitive to light, is used. The principle is the same as that involved in making ordinary prints, only different devices must be used on account of the great length of film. The negative images are printed on the positive film by running both films through a "printer."

Throwing pictures on the screen. For showing pictures on the screen, three essentials are needed: a projecting apparatus, a source of strong light, and a screen or white surface. This projecting apparatus is the same in principle as the stereopticon, or magic lantern, the chief difference being in the mechanism by which the film is passed through the machine.

Parts of a stereopticon. The essential parts of a stereopticon are shown in figure 176. These consist of a source of light *A*; a set of condensing lenses *C*, which concentrate the light upon the lantern slide *S*; and the lens *L* to focus this light upon the screen *S′*. Since this lens inverts the image, the slide is placed in the holder upside down.

Projecting apparatus. The delicate part of the moving-picture lantern is the mechanism by which the film is passed through the machine. This film must have a jerky motion, as in the camera, so as to stop for a fraction of a second to allow light to pass through and throw a distinct image on the screen. The film is mounted on a spool and led over a toothed sprocket which fits into the holes along the sides of the film. A loop is then formed, and the film passes into the gate behind the lens. As the shutter revolves, shutting off the light from the picture, the film is given a jerk downwards, thus bringing the next picture into the gate in exactly the same position as the previous one. The film is then connected with another sprocket and is finally rolled up on another spool. The machine may be operated either by hand or by motor. These pictures are thrown upon the screen at the rate of sixteen per second. After the film has been used, it must be wound on another reel, so as to bring the first picture into its proper position again.

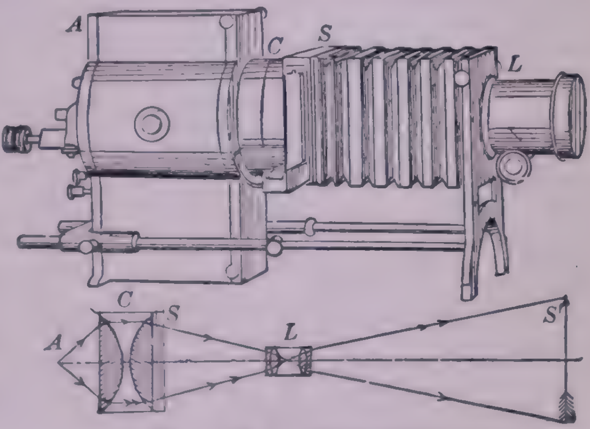

Fig. 176. — Stereopticon

FIELD EXERCISE 7

Purpose. To visit a moving-picture theater to see how the projecting apparatus works.

Directions. Arrangements should be made with the manager of some moving-picture theater to have the class visit the theater when it is not being used, in order to see how the projecting machine works. The operator can explain the details of the operation. At the next meeting of the class the points observed should be discussed. If the class is large, a section may be taken and a report made by them to the class.

The eye and moving pictures. In order to understand the action of moving pictures, we must understand not only the camera by which they are taken and the projector by which they are thrown on the screen, but also the eye which sees them. The machine throws on the screen about sixteen pictures a second, which occupy a foot of film. The screen is darkened about half the time. Why do we not see these pictures as so many distinct images, separated by brief periods of darkness, instead of seeing them as a continuous series of moving pictures?

The answer to this question is found in a peculiarity in the action of the eye. Rays of light pass through the pupil and are focused by the lens on the retina of the eye. This is so lined with a network of sensitive nerves that when the image is formed here impulses pass to the brain, and we have the sensation of sight. Even *after* the object has been removed from view, the image still remains on the retina for about one twenty-fourth of a second, just as though the object were in full view.

In the movies the pictures are shown so rapidly that the second picture is shown before the image of the first leaves the retina. Thus the brain sees a continuous series of pictures without any breaks between, and this gives the appearance of motion. Moving pictures are really an illusion made possible through this peculiarity of the eye.

A picture is thrown on the screen and remains visible for about one thirty-second of a second; then the screen is darkened for about the same length of time by the passage of the shutter which cuts off the light. Thus the pictures follow one another on the screen, separated by dark intervals of one thirty-second of a second. As the image of the picture stays on the retina one twenty-fourth of a second after the picture has left the screen, the brain retains this impression during the one thirty-second part of a second that the shutter cuts off the light.

The image of the second picture is thus impressed on the brain before the first leaves it, so that the brain does not see the darkened screen at all. If the pictures were run through slowly, say at the rate of only five or six a second, then we could distinguish between the pictures and the darkened screen, and there would be a flickering effect.

DEMONSTRATION 56

Purpose. To illustrate why we seem to see a continuous set of pictures at the movies.

Directions. Obtain a piece of cardboard about three inches square. Punch a hole in each of two opposite sides. Pass through each hole a piece of string about fifteen inches long and tie the ends together, making a loop. On one side of the cardboard draw a man's head in colors, or paste on it the picture of a man. On the other side draw straight vertical lines. Put a loop over each thumb and turn the cardboard till it winds up the strings. To "put the man in prison," pull the thumbs apart, thus giving a rapid rotary motion to the cardboard. The man will seem to be behind prison bars. Explain the result. How does this principle hold in the movies?[1]

Trick pictures. Many unusual effects, impossible in real life, are produced by tricks in the process of making and showing the pictures.

Stop and substitution. Many of these effects may be understood if we will remember that at any time during the taking of pictures the camera man can stop turning the camera, and then any changes desired may be made in the scene being taken. Then the camera may be started again. On the screen these various activities appear as continuous, while as a matter of fact there may have been a long lapse of time between any two consecutive pictures. For example, in picturing accidents the camera is stopped just before the accident occurs, and a dummy is substituted for the real actor; then the camera goes on taking pictures. Later the dummy is removed and the actor comes back again.

One turn, one picture. The movie camera can be used like any other camera, to take just one picture at a time. For example, to produce pictures of inanimate objects in motion, such as a plate moving across the table, this stop-motion is used. A single picture of the plate is taken; then the plate is moved a short distance and another picture is taken; and so on. When we finally see the pictures, they are thrown rapidly on the screen and seem to be in continuous action.

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[1] From Rowell's *Introduction to General Science.*

Double exposure. Many curious effects are produced by double exposure. The film is so covered with a mat that only a portion of it is exposed. It is used once, pictures being taken on the exposed portion. Then the film is rewound. The part that has been exposed is covered, and pictures are taken on the other portion. In this way one man may act the parts of twins. The portion of the film that is not exposed the first time may be a circle, in which a variety of things, such as a vision, may be made to appear in the second exposure.

Double printing. In double printing, two negative films are placed one over the other, and one positive film is made from the combination. For example, in order to make people appear very large or very small, pictures are taken at different distances, thus giving different-sized images. Then these two films are printed one over the other so that the two images appear on the screen at the same time.

Reversal of motion. In order to show such reversed effects as a wheel rolling uphill or smoke going down a chimney, a use of the camera known as reverse motion is employed. One method used is to turn the camera upside down and take the picture with the camera in this position. By another method, a certain amount of unexposed film is wound on the spool on the exposed side. The exposures are then taken while the film is being turned backwards. In both the above methods, when the pictures are finally thrown on the screen they are shown in the reverse of the order in which they were taken.

Manipulation of objects. In some cases inanimate objects which seem to move of themselves are moved by some power that does not show in the picture. For example, if the object is large, like a door, a person may be concealed behind it. Another method used is to have objects moved by wires attached to them, the wires being so small that they do not show in the picture. These wires are worked by a person who does not appear in the picture.

High-speed and slow-motion pictures. In some pictures the action as shown on the screen is very much faster or very much slower than in real life. These effects are produced by taking the pictures with the camera at one speed and then showing them on the screen at a different rate of speed. About sixteen pictures a second are shown on the screen, and pictures are usually taken by the camera at the same rate of sixteen exposures a second. If pictures are taken much faster, say at the rate of eighty exposures a second, and then shown on the screen at the usual rate of sixteen per second, the action as seen on the screen occupies five seconds; that is, the action is one fifth as fast as it was in actual life. This process may be reversed. If pictures are taken slowly, say at the rate of one exposure a second, and shown on the screen at the rate of sixteen per second, then the action occurs on the screen sixteen times as fast as it actually happened.

In order to produce pictures of a man climbing up the side of a building, a canvas is first painted so as to look like the side of a house. This is then laid on the studio floor. The camera is fastened above the stage and takes pictures while the actor crawls along the canvas.

TALKING MOVIES

Phonograph and movies. In the first attempts to develop talking movies, experiments were tried in using a phonograph in such a way that it would make records at the same time that the camera was taking pictures. Then in the theaters attempts were made to arrange the phonograph and the projection apparatus in such a way that they would work together. It was found very difficult to secure a unison perfect enough to make the results successful. While a few of these were exhibited to the public, they were not satisfactory and have been largely abandoned.

Phonofilm. In more recent years attempts have been made along a different line, which seems to offer greater promise of success. In accordance with a new discovery, sound waves are made to influence a beam of light in such a way that the sound values are photographically recorded on the edge of the film on which pictures of the play are being taken. After the film has been prepared and is ready for use in the projection apparatus, the photographically recorded sound effects are reproduced in sound; and these sounds must be in unison with the pictures because both are reproduced from the same film. Demonstrations of this method have appeared in the theaters, and short photoplays have been attempted. In the spring of 1925, while President Coolidge was delivering one of his speeches, a phonofilm was used to record his words and actions.

OUTLINE SUMMARY

MOVING PICTURES

I. Place of moving pictures in modern life

II. Features shown at the movies
  1. The photoplay
  2. Educational films
    a. Science and moving pictures
    b. Moving pictures in the schoolroom
  3. Animated newspaper
  4. Animated cartoons

- III. History of moving pictures
  - 1. Early experiments
  - 2. Developments in photography
    - *a.* Celluloid film
  - 3. Edison's kinetoscope
  - 4. Paul's animatograph
  - 5. Lumière's cinematograph
- IV. The mechanics of moving pictures
  - 1. Making the film
  - 2. The camera
  - 3. Preparing the film
  - 4. Throwing pictures on the screen
    - *a.* A stereopticon
    - *b.* Projecting apparatus
  - 5. The eye and moving pictures
  - 6. Trick pictures
    - *a.* Stop and substitution
    - *b.* One turn, one picture
    - *c.* Double exposure
    - *d.* Double printing
    - *e.* Reversal of motion
    - *f.* Manipulation of objects
    - *g.* High-speed and slow-motion pictures
- V. Talking movies
  - 1. Phonograph and movies
  - 2. Phonofilm

QUESTIONS FOR CLASS DISCUSSION

1. What were the first steps taken in the development of the moving picture?

2. What part did Thomas Edison play in the development of the moving picture?

3. What was the relation between the development of the movies and the development of photography?

4. How does the moving-picture camera work?

5. How is the film developed, and how is the positive made?

6. How are the pictures thrown on the screen?

7. What peculiarity of the action of the eye makes the moving picture possible?

8. What are some interesting educational applications made of the movies?

9. What uses could be made of moving pictures in your school?

10. How is the animated newspaper managed?

11. How are trick pictures produced?

12. Watch carefully the movies you attend and notice which ones include trick pictures. How many kinds of trick pictures can you find?

13. Which do you consider the most interesting trick pictures?

14. What are the special advantages of the talking movies?

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CHAPTER XXVIII

PROTECTION OF BIRDS

1. Why should birds be protected?
2. What is being done to protect birds?

There are in nature certain forms of life which are of such great value to man that they should be protected. Chief among these are birds and forests. In order to protect these efficiently, the coöperation of all concerned is necessary.

The subject of the protection of birds will be treated under two headings: First, why birds should be protected; and second, how birds are being and can be protected.

REASONS FOR BIRD PROTECTION

Birds should be protected for three reasons: First, because they are valuable through eating such pests as insects, weed seeds, and rats; second, because the game birds are a source of much pleasure to sportsmen; and third, because bird-lovers the country over derive much pleasure from studying the habits of our song birds.

Destruction of pests by birds. *Insects.* Studies made by the Bureau of Biological Survey at Washington have shown that insects form the chief food of birds and that many of these insects are injurious to man because they feed upon the crops he is raising or because they carry diseases. Birds help man because they keep these insects down to such a point that man is able to control those that remain. If man were to be deprived of the services of the birds, insects would increase to such an extent that man would probably have a terrible struggle to overcome them.

Amount eaten by birds. One thing that makes birds so helpful is the fact that they devour so many insects in the course of a day. Birds watched in the field have been observed to eat from two to ninety insects in a minute, the number depending on the bird and the kind of insect. In the studies made by the Biological Survey it was found that the stomach of a single bird contained a great many insects. For instance, the stomach of a grosbeak was found to contain fourteen potato beetles; of a crow blackbird, thirty grasshoppers; of a flicker, five thousand ants; and the stomach of a nighthawk contained two wasps, three beetles, three hundred and forty grasshoppers, and fifty-two other insects.

It was learned also that a single species of bird feeds on a great many kinds of insects. For example, the downy woodpecker was found to eat forty-three different kinds of insects; the robin, two hundred and twenty-three kinds; and the nighthawk, six hundred kinds.

It was further found that many different kinds of birds feed upon some one kind of insect. For example, twenty-six kinds have been found to feed upon the potato beetle; thirty-six kinds, on the codling moth (the caterpillar of which is the worm of wormy apples); eighty-eight kinds, on cutworms; and one hundred and twenty-eight kinds, on the click beetles or their larvæ (the wireworms).

Food of nestlings. Nestling birds require vast amounts of food and are fed frequently during the day, beginning at sunrise and continuing till sunset. One pair of house wrens was observed to feed its young two hundred and thirty-eight times in one day. During the two weeks these young were in the nest, they ate from four thousand to five thousand insects. Observations made of many young birds show that it is a common thing for birds to feed their young two hundred times in one day, or about once every four minutes.

One man, after watching a pair of marsh wrens carrying grasshoppers to their young, estimated that the grasshoppers eaten by all the birds in eastern Nebraska in one day would have destroyed about seventeen hundred dollars' worth of crops had it not been for the birds. Another man estimates that the birds of New York State destroy annually more than three million bushels of injurious insects.

FIELD EXERCISE 8

Purpose. To see how many times nestling birds are fed in one day.

Directions. A nest of some bird should be located that can conveniently be watched. The class may be divided into small groups and each group assigned to watch the birds for a certain length of time, say an hour. A record should be kept of the number of times the young birds are fed, and, if the sexes can be distinguished either by color or by song, the number of times each parent brings food should be recorded. The birds feed from sunrise till sunset; if there are not enough groups to watch them all day, an estimate for the whole day may be made from the results obtained for the time the birds are watched.

Number of insects eaten. It is possible to make an estimate of the number of insects eaten by birds east of the Mississippi River. A census has been made of the number of birds found here, and observations have been made of the number of times young birds are fed. From these sources we get an estimate that ten trillion insects are eaten each summer by the birds east of the Mississippi River. If these insects were placed an inch apart, they would make a procession a hundred and sixty million miles long, which would reach to the sun and almost back. If it traveled at the rate of one mile a minute, it would take three hundred years to pass a given point. If placed one inch apart each way, the insects would make a sheet that would completely cover the state of Delaware.

Birds as destroyers of weed seeds. A second way in which birds help man is by eating weed seeds. The most valuable birds for this purpose are the mourning dove, the horned lark, the bobwhite, and the native sparrows. Two thirds of the entire food of the dove and the lark, and about one half of the food of the bobwhite and the sparrows, is composed of weed seeds.

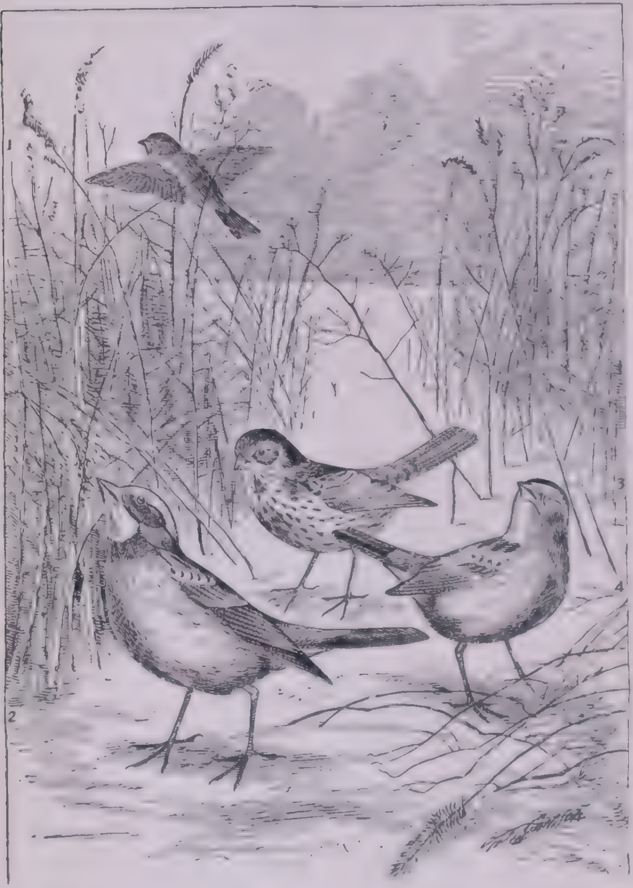


Fig. 177. — Four common seed-eating birds
1, Junco; 2, White-throated sparrow; 3, Fox sparrow; 4, Tree sparrow

The red-winged blackbird has been known to eat fourteen kinds of weed seeds; the horned lark, thirty-eight kinds; and the bobwhite, one hundred and twenty-nine kinds.

A single bird eats an enormous number of seeds. In a single stomach of a chipping sparrow have been found one hundred and fifty seeds of crab-grass; and in that of a bobwhite, ten thousand seeds of pigweed. Professor Beal has estimated that the tree sparrows in the state of Iowa alone consume every year eight hundred and seventy-five tons of weed seeds.

Most of the work of eating weed seeds is done between early autumn and late spring. During the summer, birds feed largely on insects. This group of birds is beneficial, then, in two ways — in eating insects and in eating weed seeds.

Destroyers of rodent pests. Still a third way in which birds

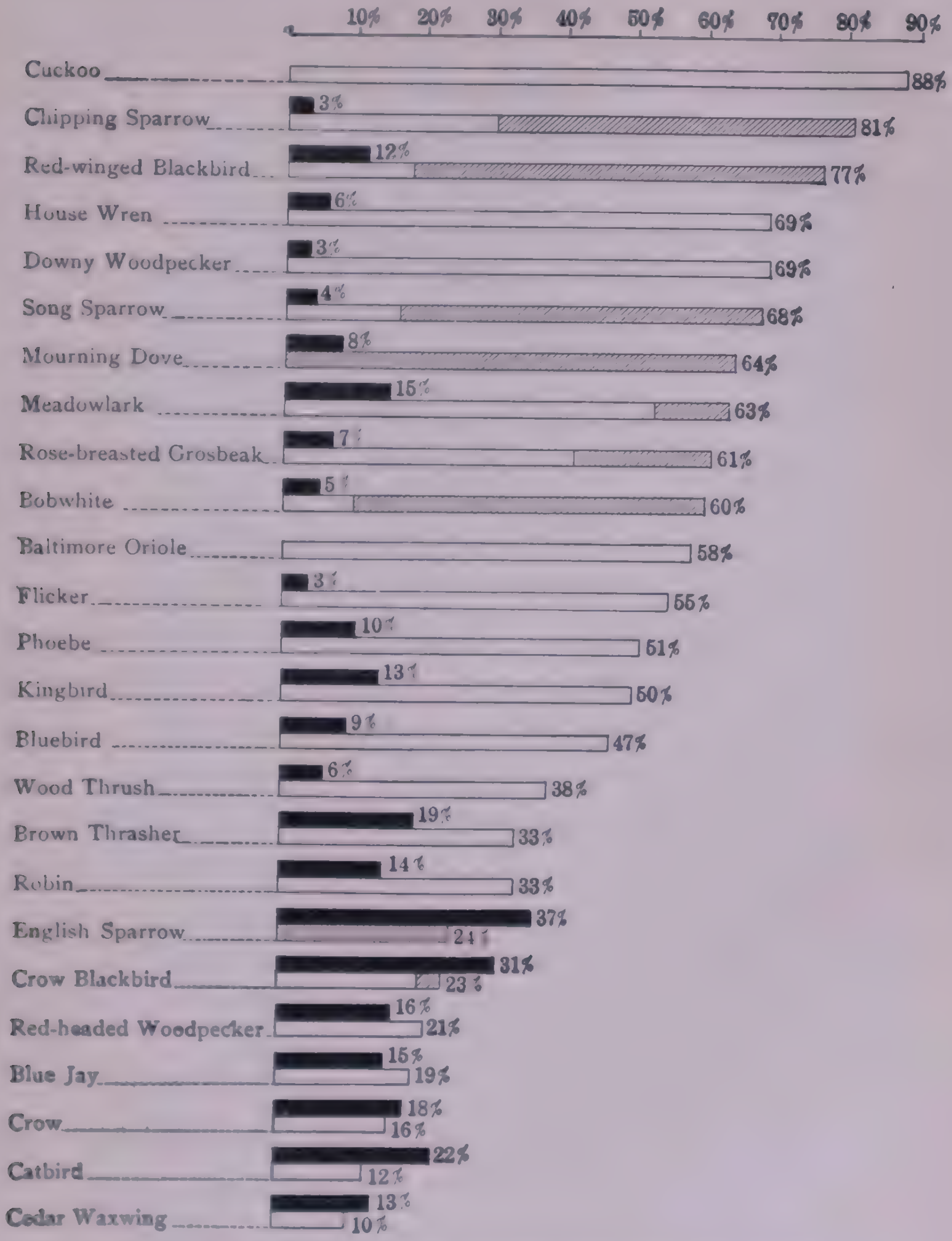


Fig. 178. — Food chart of twenty-five common birds

The upper, black bar represents food to the bird's discredit (grain, cultivated fruit, beneficial insects); the lower bar represents food to the bird's credit (☐ injurious insects; ▨ weed seeds). The length of line is based on the percentage that these foods form of the bird's total food, as determined by the Bureau of Biological Survey.

help man is by destroying rodent pests, such as rats, mice, and ground squirrels. The birds that are helpful in this way are the hawks and the owls. These birds have been greatly misjudged. Because a few hawks destroy some poultry, the wrong notion is somewhat common that all hawks and owls are injurious. As a matter of fact, only two common hawks — Cooper's hawk and the sharp-shinned hawk — are injurious; and no common owl is injurious. There are several hawks that may occasionally take a chicken; but this is the exception, and it is made up many times by the good they do. About 10 per cent of the species of hawks and owls are injurious, 15 per cent are neutral, and 75 per cent are beneficial. That is, more than seven times as many species are beneficial as are injurious.

Eight mice have been found in the stomach of a single hawk. It seems fair to suppose that a hawk or an owl would destroy at least one thousand mice a year. It has been estimated that a mouse will do two cents' worth of damage in a year. Therefore these one thousand mice would have done twenty dollars' worth of damage if they had not been destroyed by this bird. A hawk or an owl, then, may be said to be worth twenty dollars a year.

Harm done by birds. On the other hand, a little harm is done by some birds. Some, like the catbird and the cedar waxwing, feed on cultivated fruit. Other birds, such as the English sparrow, the crow blackbird, and the crow, feed on grain. However, since about half of this is waste grain, it should not all be counted against the bird. As already mentioned, some hawks and owls destroy poultry. The worst offender is Cooper's hawk. The sapsucker does damage to trees by drilling holes. While the tree is sometimes killed, the chief damage is due to the fact that, after the tree is cut down and sawed up into lumber, the little holes formed in drilling lessen the value of the lumber. Some birds, such as flycatchers and swallows, eat beneficial insects. And finally, some birds destroy other birds that are valuable. More than half of the food of the sharp-shinned hawk consists of small valuable birds.

Summary. We may summarize briefly by saying that birds may be divided into three groups: injurious, neutral, and beneficial. To the injurious group belong four common birds: the English sparrow, the sapsucker, Cooper's hawk, and the sharp-shinned hawk. To the neutral group, in which the harm and the good about balance, belong five common birds: the catbird, the cedar bird, the crow, the crow blackbird, and the bluejay. The remaining common birds are beneficial — that is, they do more good than harm. If we take one hundred as the number of species of common birds that might be found in a locality, they would be divided as follows: injurious, 4 per cent; neutral, 5 per cent; beneficial, 91 per cent. To state the matter more briefly, 4 per cent do more harm than good, and 91 per cent do more good than harm; that is, for every species of harmful bird there are twenty-two species of beneficial birds.

Mr. H. W. Henshaw, chief of the Bureau of Biological Survey, writes in a recent article: "What would happen were birds exterminated, no one can foretell with absolute certainty; but it is more than likely, nay, it is almost certain, that within a limited time not only would successful agriculture become impossible, but the destruction of the greater part of vegetation would follow. It is believed that a permanent reduction in the number of our birds, even if no species are exterminated, will inevitably be followed by disastrous consequences."

The habits of a few common birds are briefly summarized in figure 178. Since about half of the grain eaten by birds is waste grain, this part has been subtracted, leaving only that portion which can be considered to the bird's discredit.

Value of game birds. Game birds are a source of pleasure to many thousands of sportsmen. The appeal of the sport brings many men out into the outdoors and furnishes a valuable recreation. It is estimated that there are about six million sportsmen in this country who go out in the autumn to enjoy the sport of hunting. The enjoyment comes not merely in the act of shooting the bird, but in all those features that go with a hunting trip. The pursuit of the game is the incentive that draws men outdoors. There is the further value of the game birds as food, but this is really secondary to the main appeal of the sport.

Bird study as a hobby. Then, finally, there is the great army of bird-lovers who derive a large amount of pleasure through studying the habits of our common song birds. This interest in birds is widespread and is evidenced by the number of bird books sold, by the birdhouses people are putting up in their yards, and by the number of bird clubs formed, both in school and out. In 1925 there were 125 bird societies affiliated with the National Audubon Society, and there were organized in the schools 7,229 Junior Audubon Clubs with a total membership of 299,305. When so many people enjoy studying the habits of these interesting birds, it is evident that birds are serving a very useful purpose and hence should be protected.

FIELD EXERCISE 9

Purpose. To learn what beneficial birds are common in your locality.

Directions. 1. In order to find what birds are common in the locality, field trips may be taken with the purpose of identifying as many birds as possible. The spring is the best time to study birds in the field. For each bird seen, a record should be made in the field of some of the following points: (1) size (compare with robin or English sparrow); (2) general colors above and below; (3) more detailed description of colors found on head, back, tail, wings, and breast; (4) any peculiarity of flight; (5) characteristics of song; and (6) the most conspicuous field marks by which the bird may be identified again.

2. After returning from the field, look up in the food chart on page 471 the economic standing of each bird seen.

METHODS OF PROTECTING BIRDS

Having shown that birds are of great value to man, we may next ask what is being done to protect birds and what should be done.

Audubon Societies. The most important organization in this country in the cause of bird protection is the National Association of Audubon Societies. At first, separate state Audubon Societies were formed. Later, a national organization was formed, the state societies coöperating with it. The work of the national association has been extended in many lines, including (1) legislation, (2) publications, (3) Junior Audubon classes, and (4) field agents.

The association has been active in getting proper bird laws passed. A number of years ago a model bird law for song birds was proposed ; this has now been adopted in forty states. Laws giving better protection to game birds have been passed as a result of the activities of this association.

The association publishes a magazine, called *Bird Lore*, which contains notes and illustrated articles on birds. A large number of colored pictures and leaflets are published, amounting to four million copies annually. These pictures are sold for five cents each.

During the past five or six years, a great work has been done in schools through the organization of bird clubs among the children. The work has grown in importance each year; and in 1924, as already stated, the membership amounted to almost three hundred thousand.

A number of lecturers, called field agents, are employed, who devote their time to lecturing on birds and aiding the work of the association in other ways.

There are now state Audubon Societies in thirty-seven states and in the District of Columbia. These coöperate with the national association and also carry on other lines of work independently.

Bird protection by governments. Much progress has been made in this country in protecting birds by state laws. The tendency in the making of these state laws has always been to give more complete protection to birds. During recent years the national government has taken important steps to protect birds, recognizing the fact that, since birds migrate from one state to another, their protection is a matter for the national government.

In 1913 Congress passed the migratory bird law. In accordance with this, all migratory birds that pass from one state to another are given some degree of protection by the national government. The exact regulations were worked out by a committee of experts from the Bureau of Biological Survey. These regulations are the most important scientific document ever issued in the cause of bird protection.

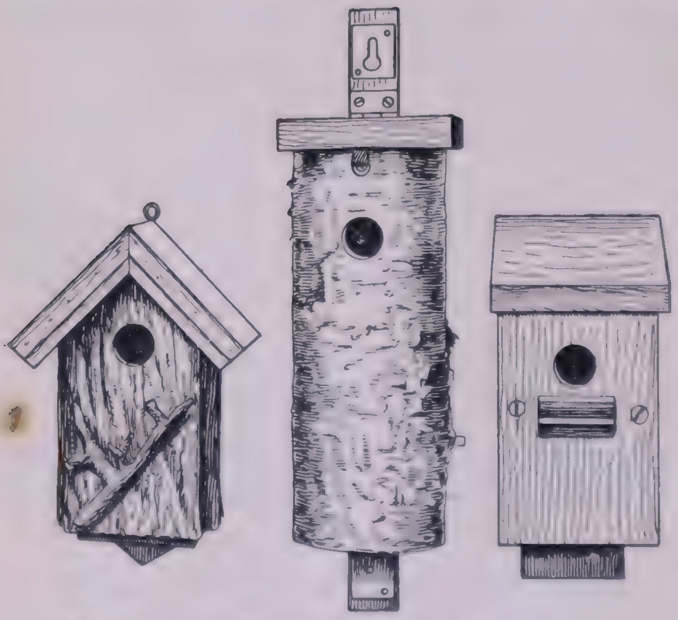


Fig. 179. — Three types of nesting boxes

Migratory birds are first divided into two groups, the insect-eating birds and the game birds. Insect-eating birds are protected during all the year. Some game birds that are [illegible]ing scarce, such as most of the shore birds, are given com[illegible]tection for a period of years. The other game birds are given protection for about nine months, an open season of about three months being allowed in the autumn. In 1918 this migratory bird law was replaced by the bird treaty with Canada. This grants the same sort of protection provided by the migratory bird law.

Another thing the government has been doing to protect birds has been to set aside bird reservations, where birds receive complete protection at all times. The first reservation was set aside in 1903. Since that time others have been added till now there are nearly one hundred.

Helping the birds around our homes. Much can also be done to help the birds that come around our yards. This help can be given along three lines: first, to provide nesting boxes; second, to feed the winter birds; and third, to provide water for drinking and bathing during the summer. Not only will the birds be helped by these activities, but people also will receive benefit, both in the pleasure they derive from watching the birds and in the practical good that the birds do in destroying the harmful insects found in the garden.

Fig. 180. — Cat with robin

This cat was seen to kill fifty-eight birds in one season.

What remains to be done. One of the chief problems still remaining is the provision of more adequate protection for the game birds. It is common knowledge among old hunters that game is not nearly so plentiful today as it was years ago. Bird authorities all agree that there has been a very marked decrease in the numbers of the game birds during the last seventy-five years. This decrease has been due largely to excessive shooting. Formerly, birds were shot for sale in the market and were killed during all seasons. The shooting for market has now been prohibited by law, and shooting for sport has been limited to a few months in the autumn. But before these measures had been taken, the numbers of the birds had become greatly lessened.

Fig. 181. — Nest and nestlings of little green herons

The number of hunters in this country at the present time is estimated to be between five and six millions. It is evident that such a large army must shoot large numbers of birds. The state of Minnesota has a law requiring each hunter at the end of the hunting season to file a report of the kind and number of game birds shot. The total number reported to be shot by the hunters in this state is two million each year, or an average of between twenty-five and thirty birds to each hunter. If anything like this average prevails throughout the country, it seems clear that something must be done to protect the remaining birds if there are to be enough left in the years to come so that the people of future generations may have an opportunity to enjoy the sport of hunting.

In order to bring about this end, many bird students believe that it is necessary to enact laws along the following lines: first, to establish more reservations where birds are protected during the entire year; second, to shorten the open season for hunting; and third, to reduce the bag limit — the number of birds that may be shot.

COMMUNITY PROJECT 3

Purpose. To see what the class can do to help protect the valuable birds found in the locality.

Directions. 1. Form a bird club. One way to protect birds is to form a bird club. It may be a club composed of just the members of the class, or the club may be open to anyone in the school or in the community. One of the best ways is to organize an Audubon Club. Write to the National Association of Audubon Societies, 1974 Broadway, New York, for particulars. Good suggestions on forming bird clubs are found in the last chapter of Baynes's *Wild Bird Guests*, published by E. P. Dutton and Co., New York. For suggestions as to what may be done by the club, see Chapter XVII in Trafton's *Bird Friends*, published by Houghton Mifflin Co.

2. Build birdhouses to put up in the city parks. See the official who has charge of the parks and secure permission to put up birdhouses in the parks. The class may divide itself into three committees: one to look after building houses for small birds, such as wrens; a second to look after houses for medium-sized birds, such as bluebirds; and a third to look after houses for large birds, such as flickers. Care should be taken that the houses are put up in the most desirable locations — as far as possible, in the open.

3. Feed the winter birds. During the winter, many birds like the bobwhite perish for lack of food. Provide food in the parks and at feeding stations in the country. The girls in the class may help in securing the foods, and the boys may distribute it. Read pages 129–136 in Baynes's *Wild Bird Guests* for suggestions.

OUTLINE SUMMARY

Protection of Birds

- I. Reasons for bird protection
    - 1. Destruction of pests by birds
        - *a.* Insects
            - (1) Amount eaten
            - (2) Food of nestlings
            - (3) Number of insects eaten
        - *b.* Weed seeds
        - *c.* Rodents
        - *d.* Harm done
        - *e.* Summary
    - 2. Value of game birds
    - 3. Bird study as a hobby
- II. Methods of protecting birds
    - 1. Audubon Societies
    - 2. Protection by governments
    - 3. Helping birds around our homes
    - 4. What remains to be done

QUESTIONS FOR CLASS DISCUSSION

1. In which way do you think birds do more good, in eating weed seeds or in eating injurious insects?

2. What can you say regarding the amount of food that birds eat?

3. In what ways may some birds be harmful?

4. Which is greater, the good or the harm done by hawks and owls?

5. What is the National Association of Audubon Societies doing to protect birds?

6. What is the national government doing to protect birds?

7. What can your class do to protect birds?

8. Look up the laws of your state regarding both the song and the game birds.

9. Find out what organizations in your locality and state are interested in bird protection. What are they doing?

REFERENCES

Baynes, *Wild Bird Guests.* E. P. Dutton and Co., New York.
Trafton, *Bird Friends.* Houghton Mifflin Co., Boston.

CHAPTER XXIX

SHADE TREES AND FORESTS

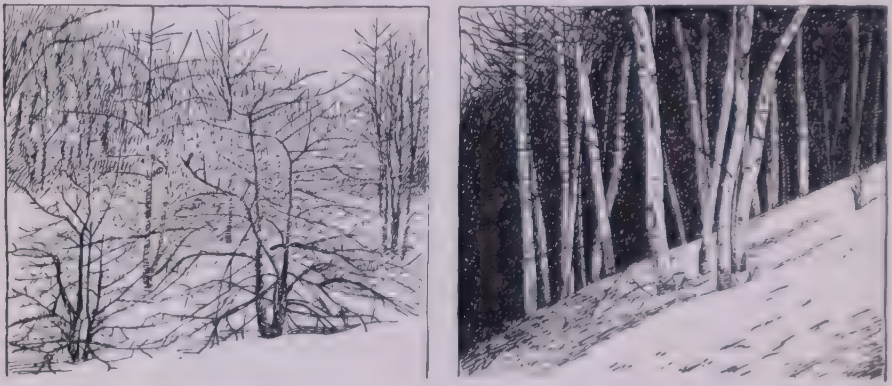
1. *What care should be given the shade trees of your town?*
2. *Why should our forests be conserved?*
3. *What is the government doing to conserve our forests?*

SHADE TREES

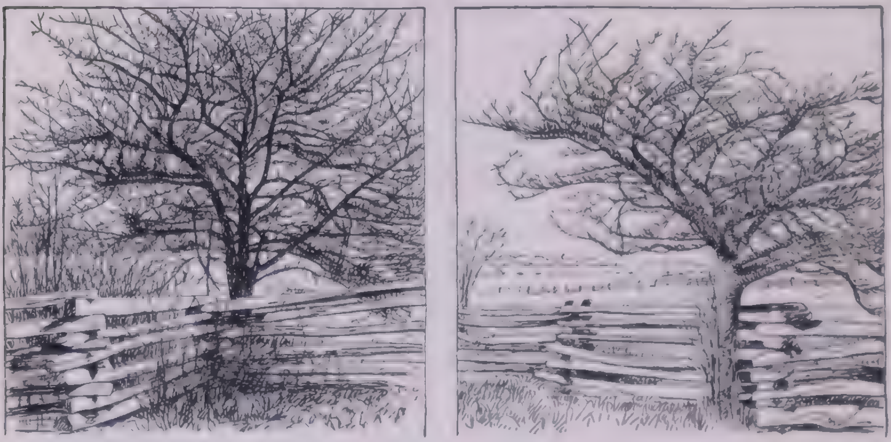
Kinds of trees. Shade trees are essential to make the streets of a town attractive. A town without trees is a barren-looking place. In the selection of trees for street planting, those species should be selected that are long-lived. Among the best trees for this purpose are American elm, sugar maple, linden, red oak, sycamore, hackberry, Norway maple, and red maple. These should be planted at such distances that they will not be crowded when mature. These distances vary from thirty feet for trees like the catalpa to fifty feet for the white elm. The mistake is often made of planting the trees too close together. In order to get quicker results, temporary plantings of rapid-growing trees, such as box elder and white maple, may be made between the long-lived trees. When these rapid-growing trees have reached such a height as to interfere with the other trees, they should be cut down.

Trees are attractive in the winter as well as in the summer. In the winter the framework is more easily seen than when the foliage is on the tree. Many trees are ornamental on account of the beauty of their branches. A close study of the twigs shows conspicuous markings by means of which the trees can be identified in the winter as surely as by their leaves in the summer.

Planting the tree. Trees may be transplanted either in the spring or in the fall, except in the extreme northern sections, where it is safer to plant in the spring. One of the chief things to consider in transplanting a tree is to reduce the amount of water given off by the leaves to the point where the roots can supply the amount lost by the leaves. Since a part of the root system is left in the ground when a tree is dug up in the nursery or woods, enough of the branches should be trimmed off to correspond with this loss of roots.



Sour gum **White birch**



Wild plum **Wild thorn-apple**

Fig. 182. — Trees in winter, showing the beauty and variety of their branches

It is important that the hole for the tree should be dug both deep and broad, so as to be larger than the root expanse. The purpose of this is to give the newly formed roots contact with a soft, freshly dug soil. When filling the hole, one should tramp down the soil firmly to make sure that it comes in contact with the roots.

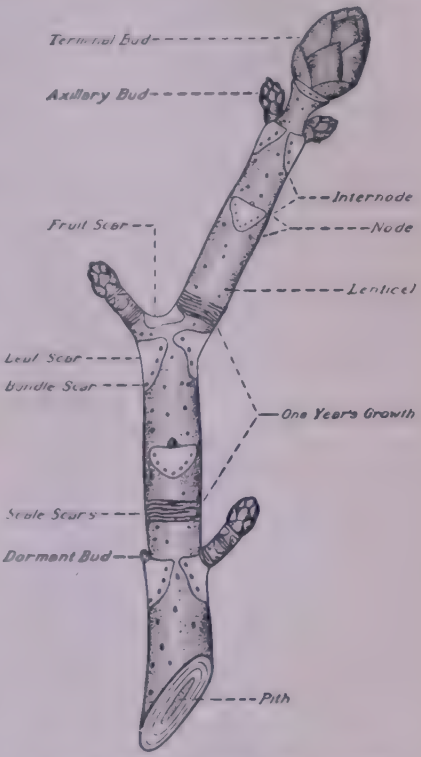


Fig. 183. — Twig of horse-chestnut

To protect the tree from mechanical injuries, it should be surrounded by a guard. An effective one may be made of wire cloth with a one-inch mesh; it should be about six feet high and completely encircle the trunk of the tree.

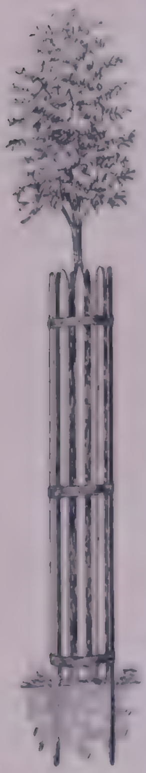


Fig. 184. — Lath tree guard

Care of shade trees. *Pruning.* In the course of the tree's growth some pruning may be necessary, to preserve the symmetry of the tree or for other reasons. In cutting off a branch, two things should be kept in mind: first, to cut in such a way that the branch will not split off a piece from the main stem; and second, to leave the wound favorable for healing. To prevent splitting, the limb should first be sawed halfway through from the under side about six inches from the main stem and then cut halfway through from the upper side about seven inches from the main stem. The branch will drop off without splitting down the bark. The remaining stub should then be cut off. This final cut should be made parallel to the main stem and close to it, instead of at right angles to the branch that is being cut, as is so often done.

If a stub is left, it hinders the healing of the wound and offers opportunity for disease spores to enter. These spores grow, and there forms a branching rootlike mass which absorbs food from the tree and thus injures it. The large fruiting bodies of these fungi are often seen projecting from wounds in trees. Unless the cut is one of a small branch two inches or less in diameter, it should be treated with coal tar or paint, the tar being preferable. If the wounds are not thus treated, the wood cracks and furnishes a resting place for the spores of disease-producing fungi. In the case of large wounds this treatment should be renewed every two or three years. If the proper care has been given, in the course of a few years the wound will be covered by the growth of a new layer of wood.

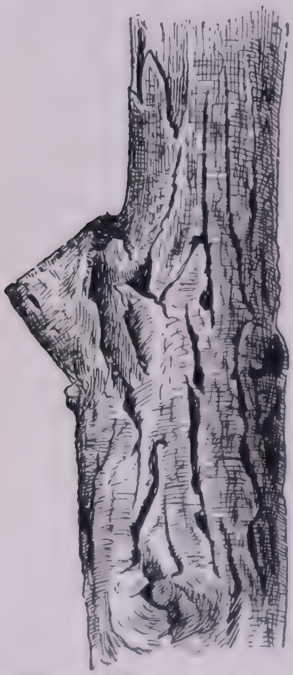


Fig. 185. — The wrong way to cut off a branch

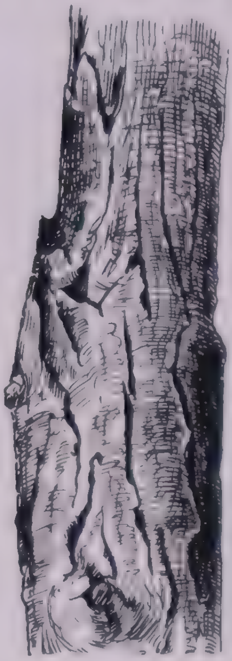


Fig. 186. — The right way to cut off a branch

Tree surgery. It frequently happens that large holes appear in some part of a tree and threaten the existence of the tree. "Tree surgery" is the name given to the methods now used to treat these cavities. The principles involved are very similar to those used in filling teeth. First, all decayed and diseased wood is removed from the cavity by means of chisels. Second, the cut surfaces are painted with some substance such as creosote in order to kill any germs of disease or decay that may be present. Third, the cut surfaces are waterproofed by painting with coal tar. Fourth, the holes are filled with cement. If the holes are large, the cement is put in by sections separated by tar paper, to prevent the cracking of the cement by the bending of the tree in the wind. The edge of the cement is shaped to meet the wood so that it stands at the level of the cambium, which grows out over the cement and in time may cover it completely.

Some trees bear large branches at such angles that there is danger of their splitting. These branches may be supported by means of bolts and chains. Holes are bored through the branches and the bolts inserted. If the branches are near together, one bolt may pass through two limbs. If they are too far apart for this, a bolt with a hook is passed through each branch, and these hooks are connected by a chain. The method sometimes used of passing bands of iron or wires around the branch girdles it and injures the tree.

Miscellaneous injuries. Shade trees are subject to injury from a number of causes, due largely to man's carelessness. Chief among these causes are the escape of gas from the mains, the regrading of streets, and the trimming of trees to make way for telephone and electric wires. In grading streets, oftentimes trees are cut down that could be saved by a little care. If the street is being cut down, the sidewalk may usually be run a little to one side of the tree and the earth left as a mound around the tree. When electric and telephone wires are being strung, the tops of trees are often cut out, leaving the trees disfigured. Every city and town should have ordinances protecting its shade trees from these and other injuries.

Protection from insects. Trees are subject to injury from a great variety of insects, which may attack every part of the tree. One group of insects, such as the elm beetle and the tussock moth, feed on the leaves; another group, called borers, gnaw their way into the bark and wood, destroying the cambium; others, as the scales, suck the sap from the leaves and other soft parts of the tree. Some insects injure the roots, and some the flower and fruit. These insects may attack the trees in such numbers that serious harm is done in a short time, or the harm may be extended over several years, the trees gradually becoming weakened, sometimes eventually dying, and in other cases living for many years in a sickly condition.

Many of these insects may be controlled by spraying the trees. For biting insects, like the elm beetle, a poison such as Paris green or lead arsenate is sprayed on the leaves, and the insects are killed by eating the poisoned leaves. For sucking insects, a poison such as kerosene emulsion is sprayed directly on the insect, killing it by contact or by clogging its breathing tubes. The boring insects are very difficult to control; but, if not present in large numbers, they may be cut out by a knife or killed by means of a wire. Pouring carbon bisulphide into the holes is very effective. Sometimes insects may be prevented from reaching the foliage by wrapping bands of sticky material around the trunk of the tree.

FIELD EXERCISE 10

Purpose. To learn what shade trees are growing in your town and whether they are properly cared for.

Directions. 1. One purpose of the field trip may be to identify the shade trees growing in the town. For this purpose the following points may be observed regarding each tree:

a. Character of bark as to color and roughness
b. Method of branching
    (1) Excurrent or deliquescent

c. Leaves
    (1) Kind — simple or compound
    (2) Arrangement — alternate or opposite
    (3) Margin — entire, toothed, or lobed
    (4) Drawing of leaf
d. Flowers
e. Fruit
f. Buds
g. Chief characters by which identified

2. Observe the trees to see if they are being properly cared for. Have the limbs been cut off correctly in pruning? Are there any wounds that need care to keep out spores of disease-forming plants? Are there any broken branches that need pruning? Are any fungi found growing on the trees? Are insects doing any serious damage?

3. If there is opportunity for planting trees around the school grounds, the class may arrange to plant some on Arbor Day.

SCHOOL PROJECT 5

Purpose. To make an exhibit of leaves of trees, to which you may invite your friends.

Directions. 1. In connection with studies of trees, it will be interesting for the class to prepare a special exhibit of tree leaves, to which they may invite their parents and friends. This may be made a very pleasant social occasion. The class may be divided into about ten divisions, each of which is to collect leaves of a certain group of trees, such as the following: the maples, the elms, the oaks, the birches, the willows, the poplars, the ashes, the nut trees, the locusts, and a miscellaneous group to include any other trees not mentioned. The members of each division will try to get all the different kinds of trees in the group assigned to them which are found growing in the locality.

2. To press the leaves, put them between the folds of newspapers, place a board on top of the pile, and on the board put some weight, such as books or stones. To mount them, secure some plain white paper and fasten the leaves to this by means of strips of gummed paper. When possible, collect the fruit as well as the leaves.

3. If these collections are made in the late autumn, they may be made more attractive by securing colored leaves.

4. To prepare for any questions that may be asked at the exhibit, look up the interesting facts about your trees.

OUR FORESTS

When the white man first settled this country, he found the forests a barrier to his progress. He was obliged to cut down the trees in order to raise the crops that would keep him and his family from famine. As he looked westward, the long line of unbroken forest hindered his march in that direction; and we may well understand that it was with great joy that the early settlers watched the forests give way to fields of grain and saw the boundary of the unbroken forest gradually recede westward.

In later years, as the market value of trees for their different products attracted attention, the commercial spirit took control and there resulted a reckless cutting of forests by private individuals, without any effective effort on the part of the government to stop or control the waste, till at the present time the larger part of our forest area has been cut over.

Present situation. That the present situation is a critical one is shown in a bulletin recently published by the government. This bulletin shows that three significant and alarming facts stand out conspicuously.

1. Lumber production has decreased since 1907.
2. The center of production is shifting to the Pacific Coast.
3. Prices of lumber have increased.

Decrease in lumber production. In the thirteen years between 1907 and 1920 the lumber production decreased 27 per cent, while at the same time population increased 15 per cent. One reason for the large amount of lumber taken from the forests is the enormous waste in converting the tree into the forms in which it is finally used. This waste amounts to about one half of the tree. There is waste in the first place in cutting the tree, later in the sawmills, and finally in the factories. Owing to the unscientific and wasteful methods of lumbering used in this country, four times as much timber is taken from the forests each year as is added by the natural growth of the trees.

As a result of the decreasing yield and the increasing population, the amount of wood used per capita has decreased from 500 feet in 1907 to 316 feet in 1920, a decrease of 37 per cent.

Center of production shifting. A second significant fact is the shifting of the center of production to the Pacific Coast. There have been six great lumber-producing areas in this country: the northeastern states, the central states, the lake states, the southern states, the Rocky Mountain states, and the Pacific states. The first three groups of states reached their maximum production about twenty-five years ago, and the southern group about ten years later. Since these dates, the production in these states has gradually been growing less. In only two groups, the Rocky Mountain states and the Pacific states, has there been an increase in production in recent years.

The northeastern and central groups of states have cut 96 per cent, and the lake group 90 per cent, of their original areas of virgin timber. Sixty-one per cent of the total remaining saw-timber is west of the Great Plains.

The change in production in the various sections is shown in the following table.

GROUP OF STATES	MAXIMUM PRODUCTION		PRODUCTION IN 1920	
	Quantity (Thousand feet)	Year	Quantity (Thousand feet)	Rank
Northeastern . .	5,640,000	1899	2,198,000	5
Central	5,511,000	1899	2,735,000	3
Lake	8,715,000	1899	2,386,000	4
Southern	10,972,000	1909	14,361,000	1
Pacific	10,355,000	1920	10,355,000	2
Rocky Mountain .	1,698,000	1920	1,698,000	6

Increase in price of lumber. The third significant fact, the increase in the price of lumber, is a natural consequence of the first two — the decrease in the production of lumber, and the shift of the center of production to the Pacific Coast.

About one half the lumber produced in the United States is used in the states east of Iowa and north of Tennessee. In previous years the average haul of lumber from the producing areas to this region has been between five hundred and one thousand miles. Now, with the main area of production in the West, a large amount of lumber must be hauled between two thousand and three thousand miles. This increased cost of freight will cause an increase in the cost of lumber to the consumer. In the year 1923 the cost of transportation from the South to New York was nine dollars per thousand, while the cost from the Pacific Coast to New York was twenty dollars.

The following table shows the increase in the price of wood. The figures give the value f.o.b. mill per thousand feet, board measure.

	1915	1916	1917	1918	1919	1920
ALL KINDS OF WOOD	$14.04	$15.32	$20.32	$24.79	$30.21	$38.42

Such is the situation. What is the solution of the problem? How are the people of this country to get enough lumber in the years to come to supply their needs at such prices that the average man can afford to buy it?

Some help may be secured by taking less lumber from the forest. Some of the waste now practiced in cutting lumber can be eliminated. To some extent the demand for lumber may be slightly lessened by using lumber substitutes. However, these measures alone are very inadequate to solve the problem. There is one and only one way left — namely, to *grow enough timber to meet the needs*. This can be done if the American people will put its will to the task. It means the application of scientific forestry to the management of our forest lands and the putting to use of the cut-over forest land now lying idle and useless. At the present time we have about eighty million acres of cut-over land awaiting reforestation. All Europe now grows its timber as a regular crop.

Uses of forests. Forests serve three great purposes: First, they act as a protective covering for the area on which they are growing; second, they are a source of wood; and third, they are a source of pleasure. The first kind of forest is called the protective forest; the second, the supply forest; and the third, the recreation forest. The first and third uses are served while the trees are still standing; the second use is served after they are cut down. By proper management, a forest may be made to serve all three of these purposes.

The value of forests as a source of wood is so evident that it needs very little explanation. To appreciate this, one has but to think of the manifold uses to which wood is put every day.

Forests as protective covers. As a protective cover, the forest serves two important purposes: First, it regulates the flow of streams; and second, it prevents erosion of the hillsides. On the forest floor is a thick layer of leaf mold, composed of the decaying leaves and twigs which fall every year to the ground. This humus covers the soil like a blanket and exerts a very important influence through its effect in controlling the water supply of streams.

When rain falls, some evaporates at once and goes back into the air; some runs off the surface and quickly gathers into streams; the rest soaks slowly down into the soil and gradually comes out again through springs and streams and through evaporation from the leaves of plants. The humus and the mossy vegetation act as a sponge. They absorb a large amount of water and give it out again gradually during the dry spells between rains. Thus they tend to prevent floods just after rains and to prevent the drying up of the streams during the dry weather. Forests tend, therefore, to give streams a regular, even flow during all the season; and this tendency exerts important influences on our daily life, as we shall see in the paragraphs that follow.

Streams for water power. Coal now supplies us with most of the power to run our factories, to furnish our electricity, and to run locomotives and other machines so essential in our life. But the supply of coal will sometime be exhausted; then man must find some other source of power. Our streams will furnish a part of that power, and the force of the flow may be used over and over at different localities on a stream. In order that the best use may be made of these streams, it is necessary that there should be an even flow throughout the whole year, so that a machine may be run all the time and not be obliged to stop because the river is low.

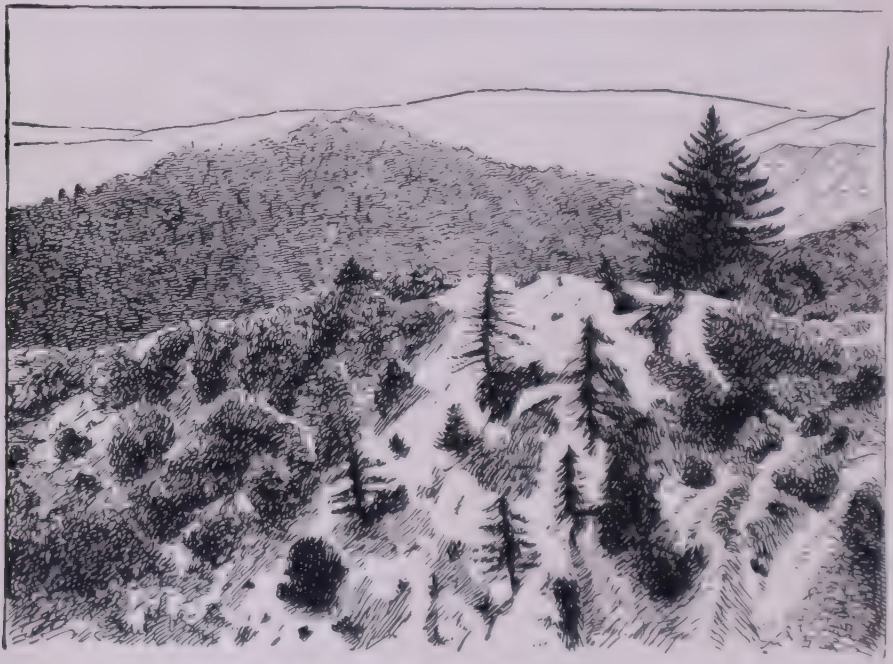


Fig. 187. — Forested watershed in the San Bernardino Mountains, California

Streams for navigation. As our country continues to grow, additional methods of transportation will be needed, and the navigable rivers furnish one important means. Here, too, it is necessary that there should be an even flow of water throughout the year, so that the river shall not be so flooded in spring nor become so low in summer that it is not navigable. It is also essential that the channel shall not be filled up with soil brought down from the hills.

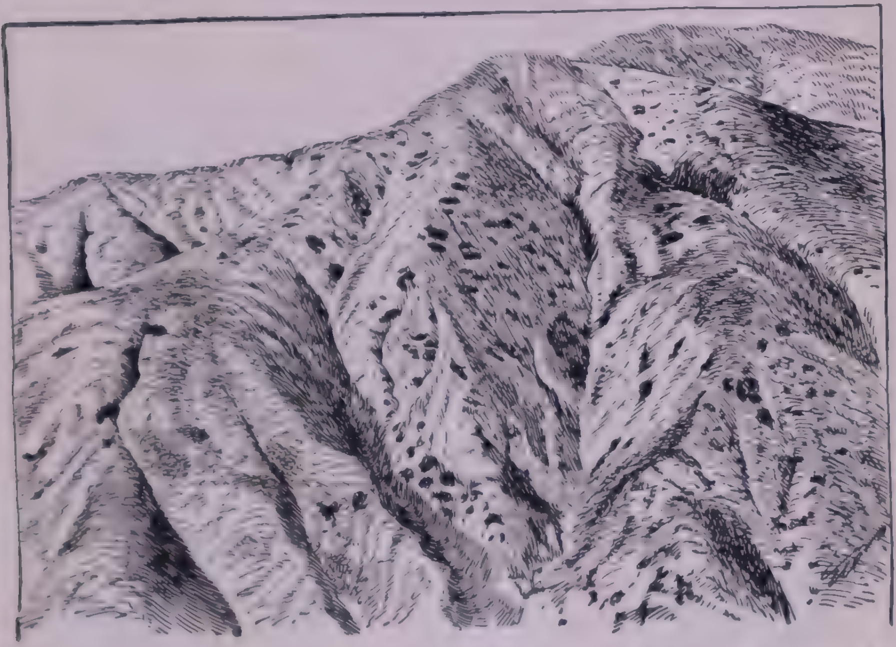


Fig. 188. — Unforested watershed in the San Bernardino Mountains, California

Streams for irrigation. In the western part of our country are vast areas barren at present on account of lack of sufficient rainfall, but with rich soil, capable of producing the best of crops and thus supporting a large population. In many cases it is possible to irrigate the land by bringing water from neighboring rivers. The United States government is undertaking large enterprises in this connection. It is of special importance here that as much of the water as possible be available during the dry season. If no rains fall in the dry season, it is essential that the rain which has fallen earlier shall be stored up and retained as long as possible on the mountain slopes so as to feed the streams constantly. In all these cases forests are essential to regulating the water supply of the streams.

Prevention of soil erosion. Another important use of the forest is to prevent soil erosion. The layer of humus prevents the rapid run-off which causes erosion, and the roots help to keep the soil in place. Where forests on hillsides have been removed, the floods wash down the soil, carrying it into the streams, thus interfering with navigation and sometimes spoiling the farms of the lowlands by deposits of gravel and sand. Sometimes these floods cause great injury to both property and life. On the steep hillsides the soil down to the solid rock may be washed away, thus making it impossible for forests to grow there again. In eroded areas where irrigation is prac-

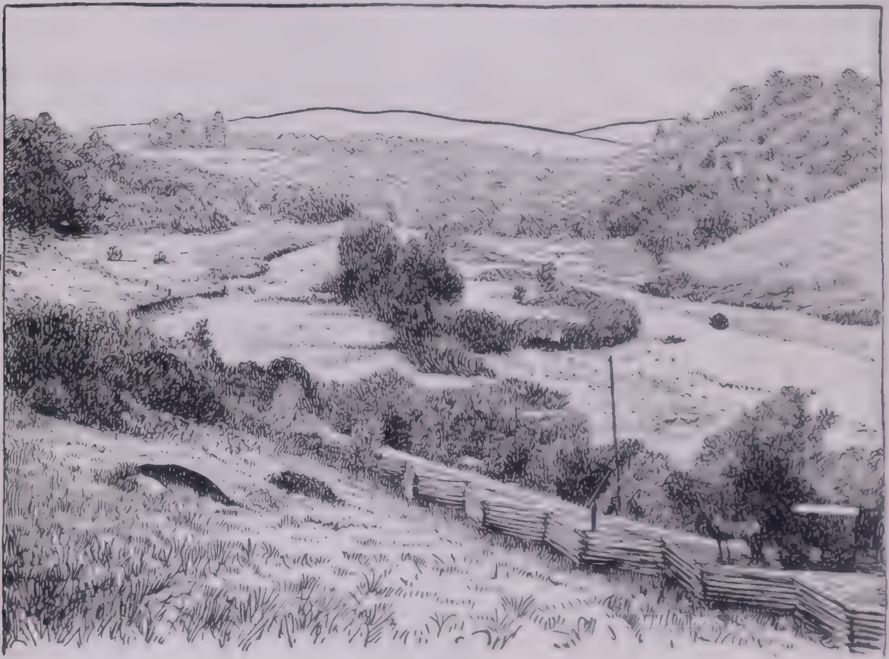


Fig. 189. — Destruction of farm land in North Carolina by flood

ticed, the silting up of reservoirs is one of the most serious problems.

In almost every country, millions of dollars' worth of property has been destroyed by floods owing to the careless removal of forests. In our own country, for instance in the state of North Carolina, land which was formerly worth $125 an acre is now useless, owing to gullies and deposits of gravel due to floods. In the San Bernardino Mountains, in California, torrents have been able to carry stones and sand into the orange groves of the San Gabriel valley because the forests on the mountains had been destroyed by fires and grazing.

Fig. 190. — A park, a place where people enjoy the outdoors

Recreation forests. The recreation forest serves an important purpose as a source of pleasure. Many travelers and campers visit the national parks and forests each summer as a means of recreation, and the smaller parks found in cities and towns are of great value to the people living near.

It is estimated that in the summer of 1921 more than five million persons entered the national forests for some kind of recreation. The chief kinds of recreation are fishing, camping, hiking, packing, automobiling, and picnicking. Hundreds of miles of trails have been built for hikers and pack animals, and many miles of roadway for automobiles and wagons. To meet the needs of the tourists, the forest service has laid out and equipped a large number of camps along these trails.

COMMUNITY PROJECT 4

Purpose. To learn the value of your city parks.

Directions. 1. Visit a park and make a list of the trees, shrubs, vines, and flowers growing there.

2. Find information on the following points regarding your city parks: number and area; money spent each year on them; care given to them; improvements made; uses made of the parks; number of people using them.

National forests. Realizing the importance of conserving our forests, the national government began in 1891 to set aside from the lands which it owned certain areas to be kept as national forests. Since that time others have been added, till today there are about 150 national forests, comprising an area of approximately 150,000,000 acres, which constitute one fifth of the forests in the United States. These are located chiefly in the western states, although national forests have recently been set aside in the White Mountains and in the Appalachian Mountains. These forests generally constitute lands which are not adapted for purposes of agriculture and can serve their best purpose by being allowed to remain in forests.

It is the intention of the government to make the forests of the greatest use to all concerned. The forests are managed with the thought of making them permanent; only the fully matured trees are cut, the smaller trees being allowed to grow to maturity. When sections of the forest lands are found which are adapted to agriculture, these are given out as farms. In some forests cattle and sheep are allowed to graze. About ten million head of stock are grazed on the national forests for part of the year. In many places the stock industry would be impossible without this summer range.

Campers and other pleasure-seekers are encouraged to use forests. Furthermore, opportunity is given here for game to increase. The purpose is not to withdraw the forests from use, as is sometimes wrongly thought, but to make them as useful as possible and to place them under scientific management.

In the care of these national forests, scientific forestry is practiced. This consists essentially in three things: first, in cutting only the large, mature trees, leaving the others to grow; second, in providing seedlings and young trees to take the place of the trees being cut; and third, in protecting the forests from fires and other enemies.

The big trees. There has been set aside as a national park an area in California that contains the famous big trees. These are the most marvelous trees in this country and perhaps in the world.

Some of the largest of these have received special names, such as "General Sherman" and "General Grant." General Sherman, the largest of all, is 279.9 feet high and 36.5 feet in diameter. It is believed to be about 3,500 years old. It was a seedling in the days of Moses. When Jesus was born, it was a youth of 1,500 summers. Thousands of the trees now standing in the Sequoia National Park were growing during the time of Caesar. Hundreds were flourishing while Babylon was in its prime. Several are older than the Pyramids of Egypt. Four thousand rings were counted on one prostrate tree. It was a large tree, two thousand years old, when David was born. It is believed by the best authorities that some of the trees now standing may be five thousand years old. It is difficult to conceive that a single individual has lived that long. The Big Trees are probably the largest and oldest living things in the world.

State forests. The state governments also are beginning to set aside forests. Thirty-five states have forestry departments, and twenty have trained foresters in charge of their work. These states have 142 forests with an area of 3,500,000 acres. Among the leaders in this line are New York, Pennsylvania, and Michigan.

United States forest service. In connection with the development of the system of national forests there has grown up, as a part of the department of agriculture, the United States forest service, whose chief duty is to look after the protection and use of the national forests. Some of the work of the service is done in Washington and some in the national forests.

The direct care of the forest is intrusted to the ranger. His most important duty is to protect the district in his charge against fires. During certain seasons he patrols his district by means of trails for the purpose of detecting fires. Another important duty of the ranger is to look after the sale of timber and to mark the trees that are to be cut. The ranger also supervises the use of the forest for the grazing of cattle and sheep. The guards are the assistants of the rangers and may be called upon to do the same kind of work.

The forest service has been an efficient agent in awakening the people of the country to the need of conserving our forests. Since 1900 the service has issued about four hundred publications with a total circulation of almost twelve million copies. Altogether the forest service now numbers about four thousand members.

Enemies of the forest. *Fires.* Fires are the most destructive enemy of the forests, the annual amount of damage being about seventeen million dollars. Each year an area equal to the combined areas of New Hampshire and Massachusetts is burned over. It is estimated that the amount of timber destroyed by fire is equal to that cut and used. Some fires have become historic on account of the amount of damage done. The Hinckley fire in Minnesota in 1894 destroyed nine towns, burned

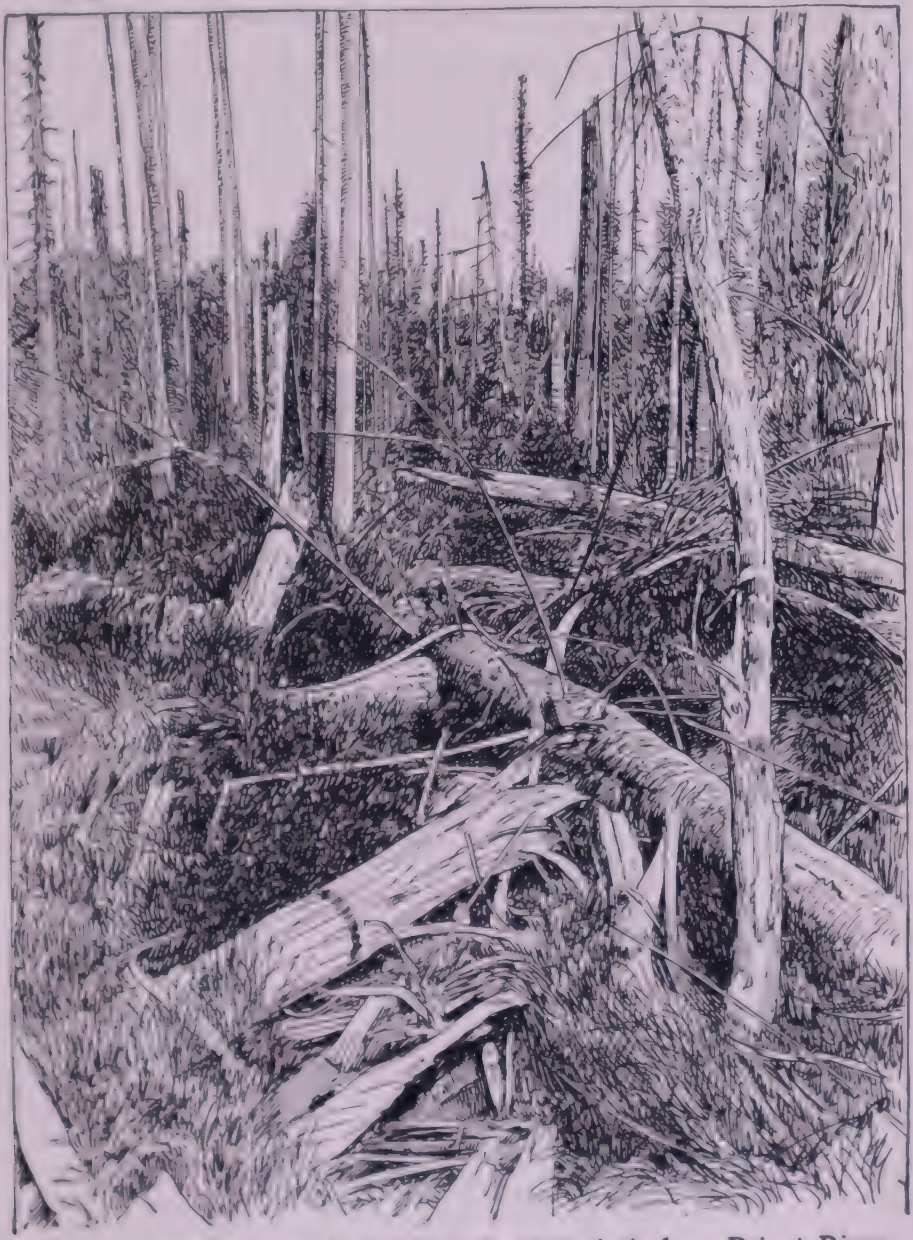


Fig. 191. — Fallen and standing fire-killed timber, Priest River Reserve, Idaho

twenty-five million dollars' worth of property, and killed six hundred people.

Harm done. Fires do harm by destroying not only the standing timber but also the young growth on which the future of the forest depends. Indirectly, harm is done also to those trees that are only partly destroyed by fire, for they are easily blown over by winds or fall easy victims to the attacks of insects and wood-destroying fungi. Sometimes enough of the humus is burned to interfere with the work of the forest in controlling the run-off and preventing floods.

Kinds of fires. Fires are frequently classified into surface, crown, and ground fires, according to the manner in which they burn. Surface fires run along the ground, consuming the leaves and twigs found there and destroying the young growth. They are the most destructive because far the most numerous. The crown fires run up into the crowns of the trees and burn the leaves and small branches. These occur only in the evergreen forests. Ground fires burn below the surface and may continue for weeks and even months without showing any signs of life, and then may break out in an unexpected place even after a heavy rain.

Causes of fires. The three most common causes of forest fires are railroads, brush-burning, and campers. These three causes are responsible for 40 per cent of all fires.

Control of fires. Most fires are due to carelessness and can be prevented if proper precautions are taken. In lumbering, proper disposal should be made of the small branches either by piling and burning them or by lopping and scattering the brush, which soon rots. Spark-arresters may be placed on locomotives to prevent the sparks from being thrown out, or oil or electricity may be used in place of coal. Fire-lanes from which inflammable material has been cleared may be constructed to prevent the spread of fires. Requiring brush-burning permits is one of the most effective means of preventing forest fires. Education is another effective means.

In the national forests, trails are made so that the rangers may patrol the forests; and lookout points and observation towers are constructed, each connected by telephone with the nearest town.

Putting out fires. Small fires may be controlled by throwing earth on them. In fighting ground fires, a trench must be dug through the forest floor down to the soil. Severe fires may be controlled by back-firing. A second fire is started some distance ahead and allowed to burn against the wind to meet the chief fire. Great care must be taken that the back fire itself does not spread. This spreading is prevented by starting it to the windward of a road, a fire line, or some other barrier which the fire can be kept from crossing.

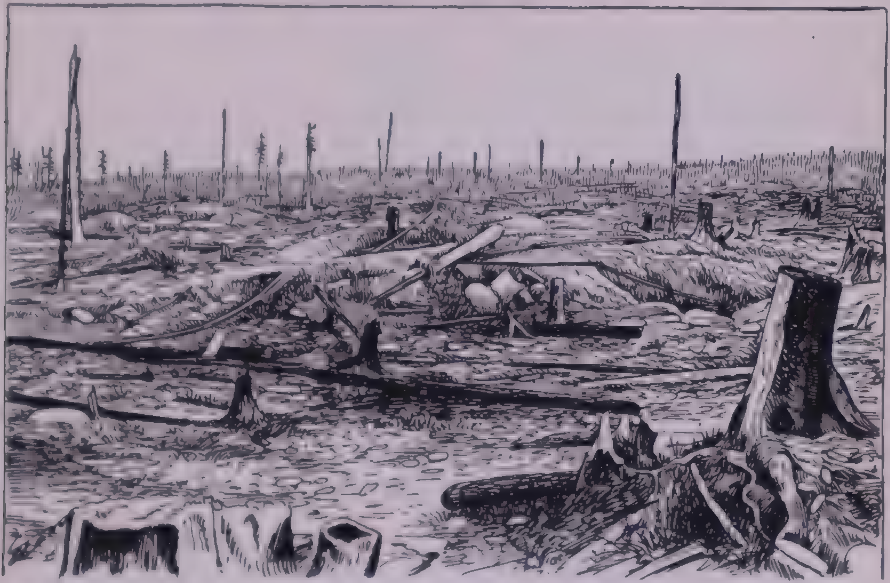


Fig. 192. — Destructive lumbering

The slash enabled fire to complete the ruin.

Destructive lumbering. One of the chief causes of the decrease of our forests has been the wasteful method of lumbering.

The general policy followed has been to cut down all the growth at one time, securing just one crop and making no plans for future returns. Usually the piles of brush left have been a means for the spread of forest fires. Sometimes this short-sighted policy has been aggravated by the fear of possible loss through fires and by high taxes which rendered it unprofitable to hold the land for more than one crop.

Insects. While there are hundreds of species of insects found attacking the forest trees, the greater amount of the damage is done by a comparatively small number of species. Some attack the living tree, some attack only the dead and dying trees, and others do harm to sawed lumber and wood products.

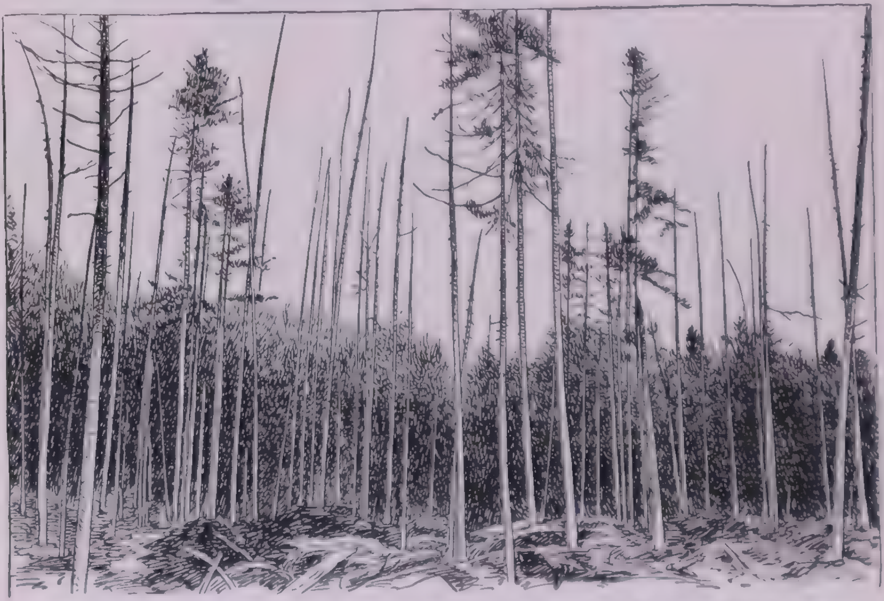


Fig. 193. — Larch trees killed by the larva of a small sawfly Adirondack Mountains, New York.

Conservation of forests. "Conservation of forests" means simply caring for the forests in a scientific manner. By proper methods of forestry, it is possible to cut some of the trees and still leave enough for protective cover. In cutting trees only a few of the largest should be cut each year, the rest being left to serve their protective purpose. A supply of young trees should be kept constantly growing to take the place of trees that are being cut out. By the proper methods of cutting the mature timber, the forest may be so managed as to give a continuous supply of timber for centuries. Through proper care the forests still left may continue to furnish almost indefinitely the supply of timber needed in this country.

The great difficulty in the past has been the wasteful and unscientific methods used and the disregard for the future. Switzerland's forests have been so well cared for during the past centuries that they are more efficient and valuable now than they were hundreds of years ago. We may attain the same condition in this country if the government will acquire a larger number of national forests and will regulate the cutting of private forests as well. This is a matter of such concern to the general good as to require government supervision. The cutting of the forests concerns not merely the men owning the forests, but

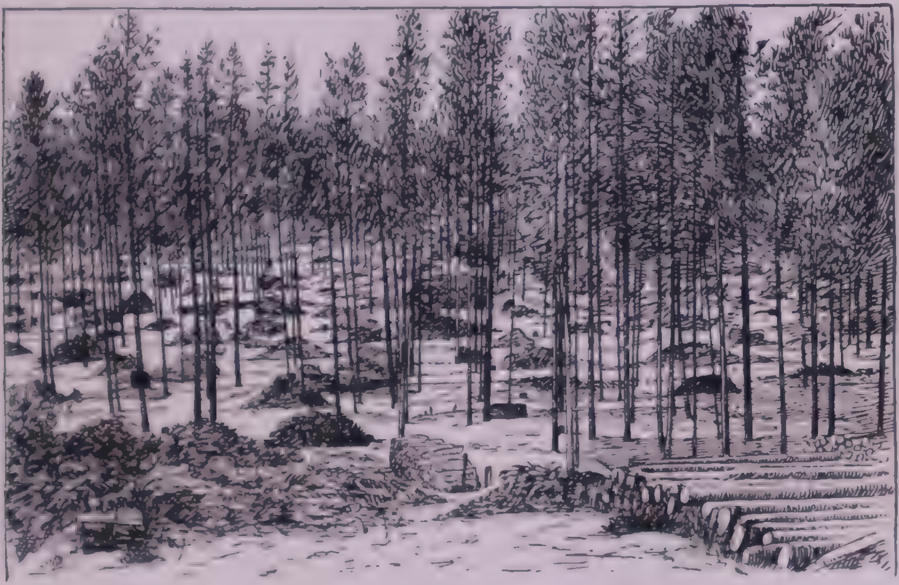


Fig. 194. — Conservative lumbering

Young growth saved; brush piled to prevent fire.

also the welfare of communities living near streams, and indeed every user of wood.

OUTLINE SUMMARY

SHADE TREES AND FORESTS

- **I.** Shade trees
  - 1. Kinds of trees
  - 2. Planting the tree
  - 3. Care of shade trees
    - *a.* Pruning
    - *b.* Tree surgery
    - *c.* Miscellaneous injuries
    - *d.* Protection from insects
- **II.** Our forests
  - 1. Present situation
    - *a.* Decrease in lumber production
    - *b.* Center of production shifting
    - *c.* Increase in price of lumber
  - 2. Uses of forests
    - *a.* Protective forests
      - (1) Streams for water power
      - (2) Streams for navigation
      - (3) Streams for irrigation
      - (4) Prevention of soil erosion
    - *b.* Recreation forests
  - 3. National forests
    - *a.* Big trees
  - 4. State forests
  - 5. United States forest service
  - 6. Enemies of forests
    - *a.* Fires
      - (1) Harm done
      - (2) Kinds of fires
      - (3) Causes of fires
      - (4) Control of fires
      - (5) Putting out fires
    - *b.* Destructive lumbering
    - *c.* Insects
  - 7. Conservation of forests

QUESTIONS FOR CLASS DISCUSSION

1. Which do you consider the most valuable type of forest: the protective, the supply, or the recreation?
2. Why is it important that the flow of streams should be kept constant?
3. What harm results from removing forests?
4. What constitutes proper care of forests?
5. How may the forests be protected from their enemies?

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CHAPTER XXX

WEATHER FORECASTING

How is it possible to foretell the weather?

The weather forms one of the most common topics of conversation when friends meet for a few minutes; it seems a most natural topic when one considers how important a part weather plays in life and how it changes from day to day. The chief factors involved in weather are temperature, wind, cloudiness, sunshine, and rainfall. The *average* weather conditions for a long time constitute climate.

TEMPERATURE

Effect of air. The source of the heat that makes life possible on this earth is the sun. And yet we receive only a very small part of the total heat given off from the sun, because we are so far away and because the earth is so small. One of the chief factors affecting the regulation of this heat is the atmosphere. Not only is the air necessary to life on account of its oxygen, but also on account of its effect in the control of the sun's heat. Were it not that the air, through the carbon dioxide and moisture it contains, acts as a blanket to keep the sun's heat on the earth, so much heat would be lost during the nights that life would become impossible on account of the very low temperatures that would result.

Change of seasons. The chief difference between summer and winter throughout most of the United States lies in the difference in temperature. During the summer we receive more heat from the sun than during the winter for two reasons: First, the sun's rays strike the earth's surface more nearly vertically; and second, the sun shines for a longer part of the day. Distance is another factor affecting the amount of heat we get from the sun. During the winter we are nearer the sun than during the summer. But this influence is so small compared with the two factors mentioned above that it is more than offset by them. In the southern hemisphere the conditions and the seasons are the reverse of those in the northern hemisphere.

The longest day in the year is not the hottest, nor is the shortest day the coldest. The longest day is June 21, while our hottest weather comes in July and August. This situation is explained by the fact that even during the period following the longest day the earth continues to receive more heat during the day than it loses during the night; hence the total amount of heat on the earth keeps increasing. The earth begins to cool only when the amount of heat lost during the night exceeds that gained during the day. This same principle explains why the shortest day is not the coldest, and also why the hottest part of the day is not at noon but a few hours later.

Factors affecting temperature. The chief factors affecting the distribution of the sun's heat, and hence the temperature at any place, are the following: latitude, height above sea level, presence of large bodies of water, direction of winds, and ocean currents. As one passes from the equator toward the poles, the temperature becomes lower at an average rate of one degree for each 62.5 miles. As one climbs a mountain, the temperature becomes lower at the average rate of one degree for each 330 feet. Hence, it is seen that a difference of 330 feet in altitude makes as much difference as 62.5 miles in latitude, or one mile up makes as much difference as one thousand miles in latitude.

The presence of large bodies of water, such as oceans, has a very important effect on temperature. These bodies help to prevent extremes of temperature. They tend to make the summers cooler and the winters warmer than would otherwise be the case. This effect is due to the fact that water warms up more slowly and also cools off more slowly than does land. Ocean currents are important factors in influencing the temperature of the ocean. However, the effect of the ocean on the neighboring lands depends on the direction in which the wind blows, whether toward or away from the ocean.

Range of temperature. One important feature which affects the attractiveness of a climate is the seasonal range of temperature — that is, the difference between the summer and winter temperatures. This range varies in different parts of the earth from only a few degrees to more than a hundred degrees. For San Diego, California, the range is 10°; for St. Paul, Minnesota, 60°. On the average the climate with a moderate range is preferable. The climate throughout most of the United States is very favorable for the development of a high type of civilization.

Besides the seasonal range, we speak also of the daily range of temperature, the range within a single day. This range affects the pleasure of living and also has a bearing on the growth of crops, especially when the lowest temperature falls below the freezing point.

MOISTURE IN THE AIR

Although we cannot see it, there is a certain amount of moisture in the air all the time, and this amount is constantly changing. In connection with the discussion of ventilation, some explanation of humidity was given in Chapter III. It may be well to read that explanation again before going on with the remainder of this chapter.

Evaporation. Water goes through a series of changes which may be divided into three stages: first, evaporation from the moist surfaces of the earth; second, a movement in the air through the action of winds; and third, precipitation in the form of rain, snow, hail, and sleet. Thus the same water is going through this cycle over and over again. A certain molecule of water may be now at one part of the earth's surface, and years later may be far away at another part; or possibly the molecule may come back to the same place in time. If it were possible for us to trace the history of a drop of water, we might find that the same molecule that fell upon our umbrella during the last storm had fallen as part of a snowflake on Washington's army in that winter at Valley Forge.

The chief source of the water that evaporates into the air is the oceans. To a lesser extent evaporation is also taking place from all moist surfaces on land and from the leaves of plants. After the air is laden with this moisture, the wind is an important factor in distributing it and carrying it long distances to places far removed from the ocean, where it falls as rain or snow.

Precipitation. The amount of moisture the air can contain depends on the temperature. As the temperature rises, the amount the air can hold increases; as the temperature is lowered, the amount decreases. The relative humidity for the eastern states ranges from 50 per cent up to 100 per cent. Before rain can fall, the air must become saturated — that is, the relative humidity becomes 100 per cent.

The conditions necessary to cause precipitation are usually brought about through a cooling of the air. For example, if the relative humidity of the air at a given time is 75 per cent, the relative humidity may be raised to 100 per cent by lowering the temperature, and then precipitation takes place. For example, as the air from the Pacific Ocean passes over the Sierra Nevada Mountains, it is cooled by being raised to a higher altitude, and a large amount of rain falls on the western side of the mountains.

Whether rain or snow falls depends on the temperature.

If the dew point is below the freezing point, snow falls; if above, rain. Snow is not frozen rain, but forms directly from the air.

The amount of rainfall in any locality determines to a large extent the kind of crops that may grow there. There is a certain minimum limit below which agricultural crops cannot be raised without irrigation. The amount of rainfall in the United States varies from less than ten inches in the American Desert to over one hundred inches on the coast of Washington.

Dew and frost. Dew and frost correspond to rain and snow, but they are formed in limited quantities only, near the surface of the ground. As the land surface cools at night, a small amount of air in contact with the earth may become so cooled that the saturation point is reached and precipitation follows. Winds and clouds tend to prevent the formation of dew and frosts — the clouds, because they act as a blanket which lessens cooling; and the winds, because they change the air that is in contact with the earth.

WINDS

Winds are a factor in our comfort or our discomfort when we are outdoors. During the summer they add to our comfort by their cooling effect; during the winter they lessen our comfort by making the cold weather more unpleasant. When looked at in a large way, however, winds are very useful, because they distribute the moisture evaporated from the ocean to lands lying in the paths of the winds.

The cause of the winds is the unequal heating of different parts of the earth, especially the equator and the poles. The principle is similar to that discussed in connection with the hot-air furnace on page 26. As a result of this unequal heating, there is a circulation of air. On either side of the equator, there is a movement toward the equator in the lower air and a movement away from the equator in the upper air.

The direction of these winds is so affected by the earth's rotation that they turn to the right in the northern hemisphere and to the left in the southern hemisphere. As a result of these factors we get the prevailing westerly winds and the regular winds known as the "trade winds." Based on the same principle, but on a smaller scale, we get land and sea breezes which blow alternately from and towards the land.

UNITED STATES WEATHER BUREAU

Having noted briefly some of the factors concerned in changes of weather, let us see what practical application is made of knowledge of these factors as applied to our everyday life. Useful application of weather knowledge is made by the United States Weather Bureau in foretelling changes of weather. This bureau is a division of the Department of Agriculture and has its main office at Washington, D.C. The observers connected with this bureau number more than three thousand. They are distributed throughout various parts of the country, some being paid and some working voluntarily. We will first notice the benefits that result from the forecasts of the Weather Bureau and then explain how it is possible to foretell the weather.

USES OF WEATHER FORECASTS

Value to fruit growers. In the springtime there is danger that the blossoms of fruit trees may be destroyed by late frosts. In some orchards arrangements are made for lighting fires quickly in order to save the orchards. When there is danger that a frost may occur, the United States Weather Bureau sends notice to the fruit growers. They then build fires and may thus be enabled to save their crops through receiving this warning. Sometimes the value of the fruit thus saved in a single night in one state has been as high as a hundred thousand dollars; and for the whole country in one year it has been as much as three million dollars. As we learned in Chapter XXI, a three million dollar fruit crop was saved in Colorado through a warning of approaching frost sent the fruit growers by the United States Weather Bureau. In the state of California alone, fruit valued at fourteen million dollars has been saved in a single year by warnings of cold waves issued by the Weather Bureau.

Protection of ships. Warnings of severe storms are sent to the leading ports on the oceans and the Great Lakes. Ship owners are thus able to regulate the sailing times of the boats; and in this way many dollars' worth of property and many lives are saved. A single storm warning has been known to keep in port vessels and cargoes valued at thirty million dollars.

Protection from floods. When floods are threatening on account of heavy rains, warnings are sent to the people living along the banks of rivers. In 1912 the Weather Bureau sent warnings to the people living along the Mississippi River that there was to be a severe flood. As a result, the people living near the river were able to remove their cattle and other property and the freight at the wharves to a place of safety. It was estimated that property to the value of sixty-one million dollars was thus saved.

It is estimated that the total value of the property saved each year through the warnings issued by the Weather Bureau is thirty million dollars.

Besides the saving of lives and property thus effected, the weather forecasts made by the bureau and printed in the daily papers are of some value to people in making their plans.

How is the Weather Bureau able to make these forecasts of weather so as to foretell frosts, storms, floods, and general weather conditions? This is done by means of the weather map. In order to understand the method of using it, we will look at the map shown in figure 195.

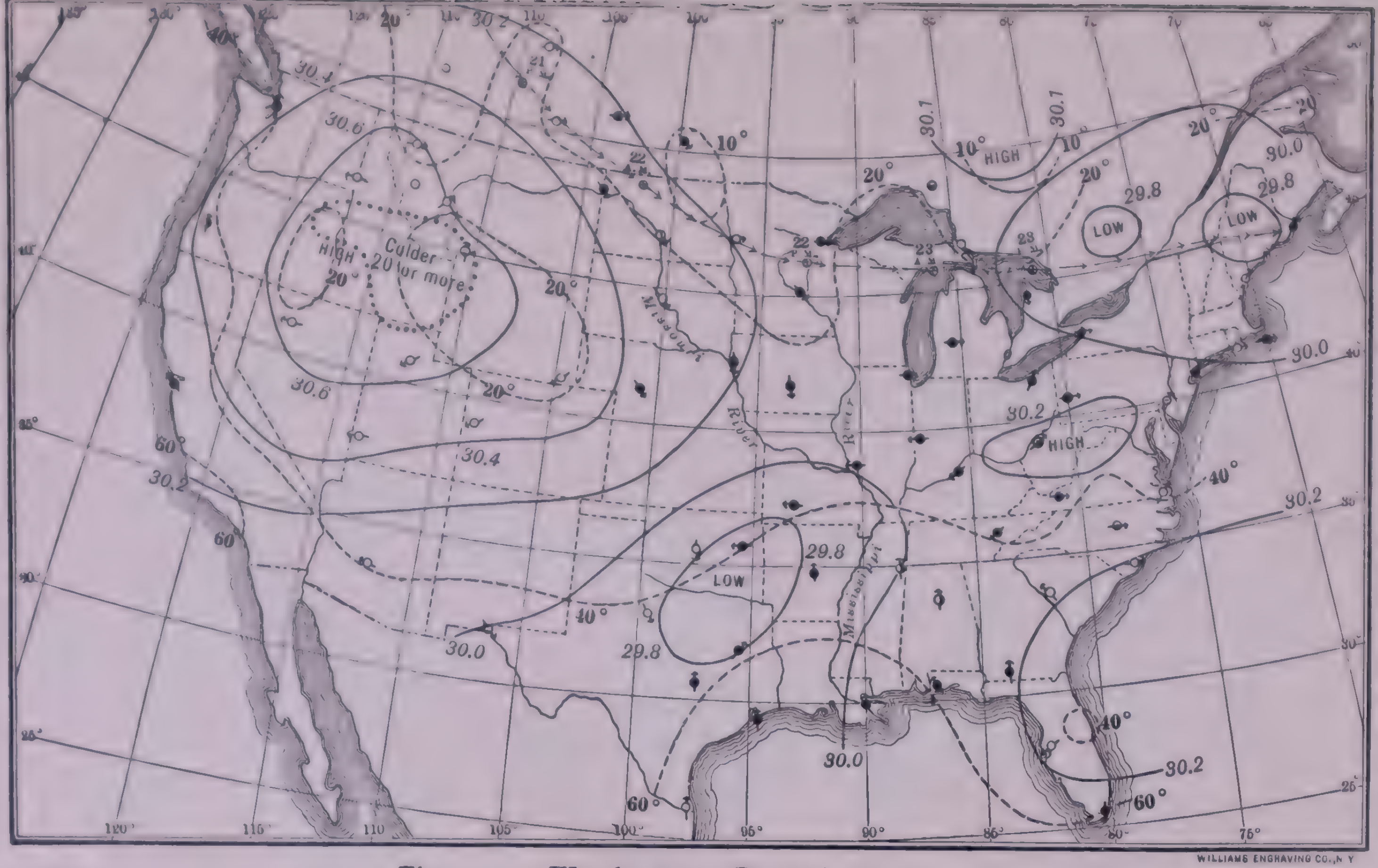

Fig. 195. — Weather map, December 24, 1915

Observations are taken at 8:00 A.M. and 8:00 P.M., 75th meridian time. Barometer readings are reduced to sea level and standard gravity. Arrows point in the direction the wind is blowing. Solid black lines are isobars, and broken lines are isotherms. Paths of storms are indicated by dotted lines with arrows. Regions where colder weather occurs are shown by dotted lines.

Symbols indicate: ○ clear, ◑ partly cloudy, ● cloudy, R rain, S snow, ⊢●→ storm warnings, CW cold wave warnings, →⊕→ storm track and location of storm center, date and time (A.M. or P.M.).

DESCRIPTION OF WEATHER MAP

Two sets of lines arranged in irregular curves are found on the map — the solid lines and the broken lines. The solid lines show the air pressure. The line marked 30.2 means that all the places through which this passes have a pressure of 30.2 inches. These lines are made for every tenth of an inch. Two kinds of areas are found on the map — "high" and "low"; these words refer to the air pressure. In general a low area, called a cyclone, is accompanied by clouds, precipitation, and warmer temperatures. The high areas, called anticyclones, are usually accompanied by clear weather and lower temperatures.

The broken lines show places of equal temperatures. For example, the line marked 40° passes through all places with a temperature of forty degrees. These lines are made for every ten degrees. Arrows are used to indicate the direction of the wind. These fly with the wind, just opposite to the way a weather vane points. The circles at the ends of the arrows indicate the state of the weather. Their meanings are given in the explanation accompanying figure 195.

On the complete maps shaded areas show precipitation of .01 inch or more during the preceding twenty-four hours. A table gives the maximum and minimum temperatures, the wind velocity in miles per hour, and the precipitation in inches during the preceding twenty-four hours. In one section are given the forecasts for the next day.

How figures are obtained. These facts regarding the weather are obtained from observers situated in about two hundred stations in various parts of the United States and Canada. Each morning at eight o'clock these observers telegraph to Washington and to other leading cities the temperature, the air pressure, the precipitation, the direction and velocity of the wind, and the condition of the sky, whether clear or cloudy.

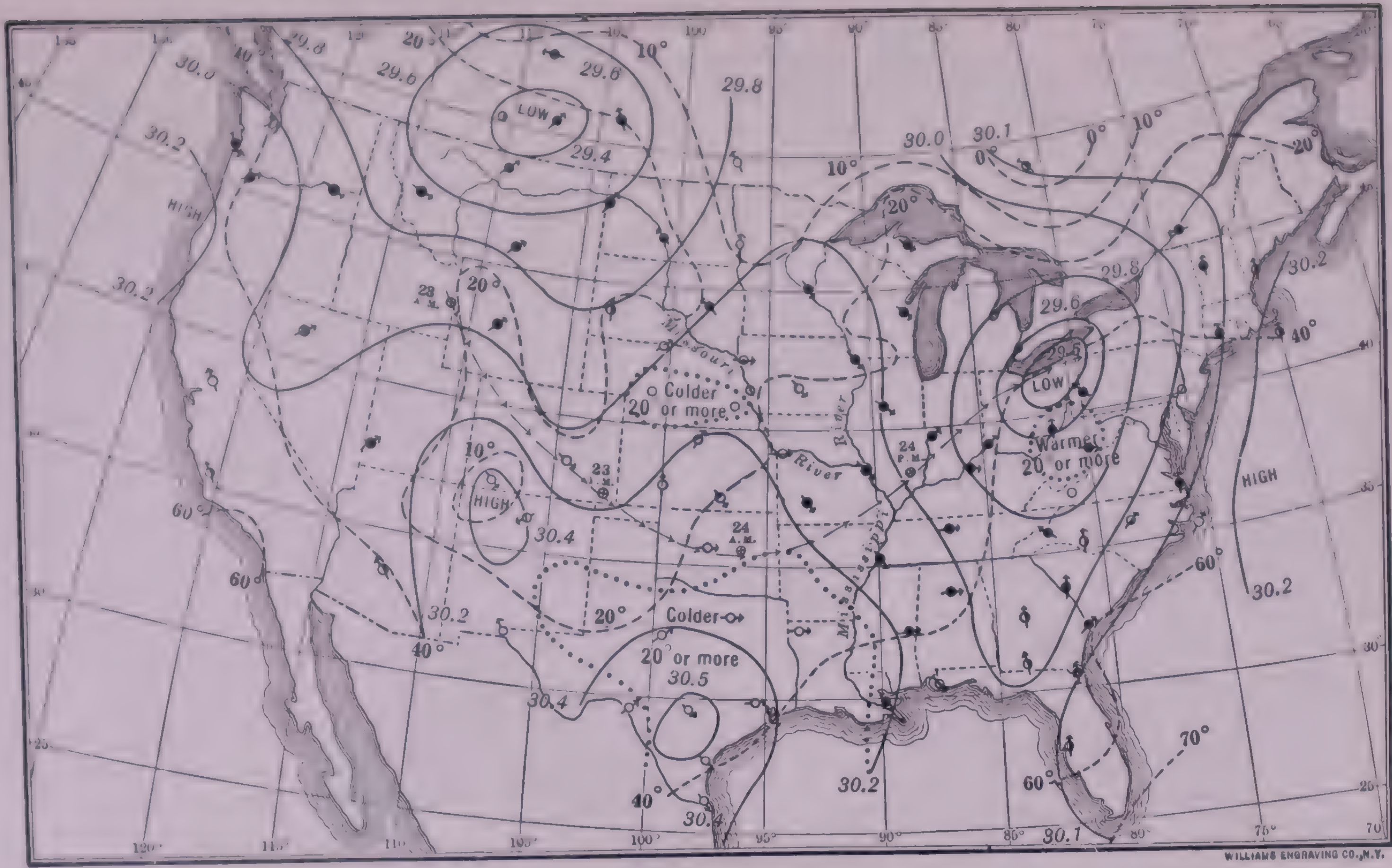

Fig. 196. — Weather map, December 25, 1915

Compare with figure 195 to note the changes in position of high and low areas.

WEATHER INSTRUMENTS

In order to measure these conditions accurately instruments are used, the chief ones being the barometer, the thermometer, and the rain gauge.

Barometer. The pressure of the air is measured by the barometer. The air that surrounds us has weight (as we have already seen in Chapter VI), although we do not ordinarily feel it. But when a strong wind is blowing, we get some idea of the reality of this weight. Some simple experiments were performed in a previous chapter to show that air has weight.

Torricelli's experiment. Nearly three hundred years ago, a man named Torricelli first performed an experiment which showed that air exerts pressure. This experiment has become historic and has been performed many times since. We will perform it now because it will help us better to understand the principle of the barometer by which air pressure is measured. We shall need a glass tube about three feet long, closed at one end, and a dish of quicksilver. The tube is filled with quicksilver, the thumb placed over the end, and the tube inverted in the dish of quicksilver. The thumb is removed after the open end of the tube is under the surface of the liquid. The quicksilver in the tube falls about six inches and then stops. It is held up by the air pressure exerted on the surface of the liquid.

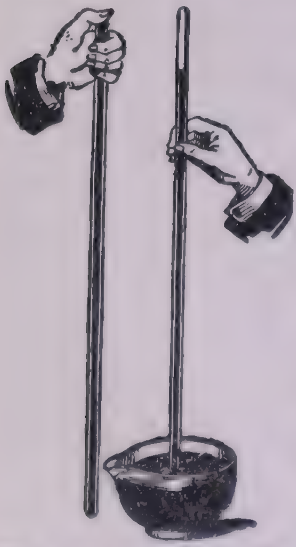

Fig. 197. — Torricelli's experiment

Construction of barometer. This experiment shows the principle used in the construction of barometers. The height of the mercury is a standard by which to measure the pressure of the air. The weight of this column of mercury is just equal to the weight of a column of air of the same diameter and extending up as far as the air goes, which is one hundred miles or more. Thus a column of air one hundred miles high is equal to the weight of a column of mercury about thirty inches high. Figure 198 shows an ordinary mercurial barometer. It is built on the principle of the apparatus used in Torricelli's experiment. The tube above the mercury contains a vacuum; there is no air there to prevent the mercury from moving up the tube.

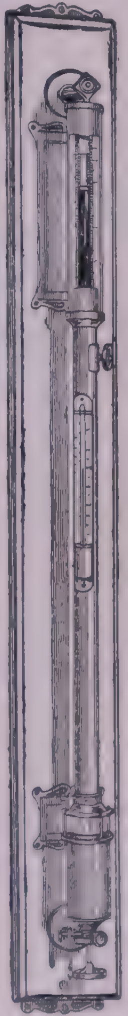

Fig. 198. — A standard barometer

Principle of barometer. The pressure of the air is constantly changing. When the pressure becomes greater, the mercury in the tube rises; and when the pressure becomes less, the mercury falls. Thus a change in the height of the mercury shows a change in the pressure of the air. This pressure is measured in terms of the height of the mercury column in inches. Thirty inches is the average pressure at sea level. This means that the air exerts a pressure of about fifteen pounds on every square inch on which it rests, or a pressure of about a ton on every square foot. The reason that buildings and other objects are not crushed by this weight is that the air pressure underneath and within hollow objects is equal to the pressure bearing down, and so the two balance.

Use in weather predictions. The barometer is a very important instrument in making weather observations, because the air pressure is the most important factor in foretelling weather changes. In general a rising barometer indicates fair weather, while a falling barometer indicates stormy weather.

Use for measuring heights. As one goes up a mountain or up in a balloon, the amount of air above one becomes less and bears down on the mercury of a barometer less heavily; therefore the column of mercury falls. On account of this fact the barometer can be used to determine heights of mountains and other elevations. The higher one goes, the lower the mercury drops. For the first mile, the mercury drops about one inch for every thousand feet. At a height of two miles the mercury drops to twenty inches.

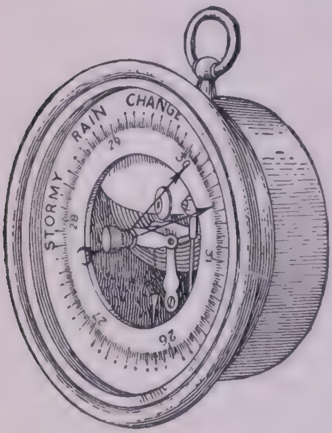

Fig. 199. — Aneroid barometer

Aneroid barometer. As the mercurial barometer is awkward to carry, another form called the aneroid barometer is used to determine elevation; as shown in figure 199, this looks something like a clock. On the inside is a box with sides of thin metal which are pressed down by the weight of the air. Connected with the sides is a hand on the front which records the pressure.

DEMONSTRATION 57

Purpose. To find the height of a hill by means of a barometer.

Directions. Take the reading of the barometer at the top of the hill. Take it again at the bottom. Subtract the smaller number from the larger. The approximate height in feet may be found by multiplying by 90 the difference expressed in tenths of an inch.

Thermometer. For measuring the prevailing temperature the thermometer is used, as explained in Chapter II. Besides this, maximum and minimum thermometers are used to record the highest and the lowest temperatures. These thermometers will register the highest and the lowest temperatures for the time they are left. They are usually set every day. The maximum thermometer is constructed so that some of the mercury remains at the highest point to which it is forced. The minimum thermometer is so constructed that a small index moves with the liquid and remains at the lowest point reached. Each of these indicators can then be set again.

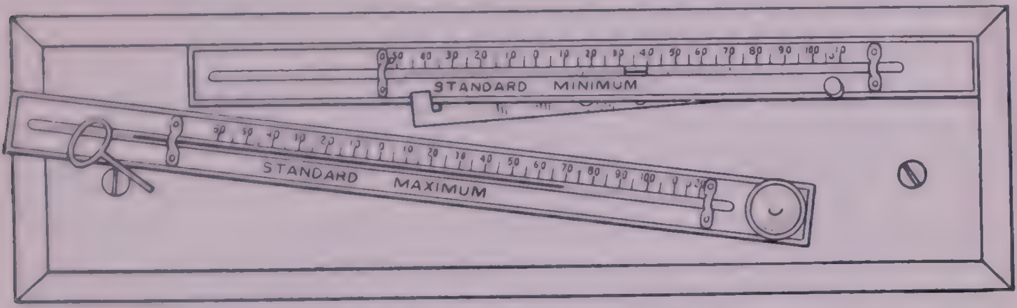

Fig. 200. — Minimum and maximum thermometers

Rain gauge. In order to measure the amount of rain, a rain gauge is used (figure 201). This is so constructed that the area of the top of the funnel that receives the rain is ten times the area of the small tube in which the water collects. This raises the level of the water ten times as high and makes it easier to read. The level is measured by means of a ruler, and the result is divided by ten to get the true rainfall. In order to measure snow, a volume equal in area to the top of the funnel and as deep as the fall of snow is collected and melted, and the water is measured as the rain is.

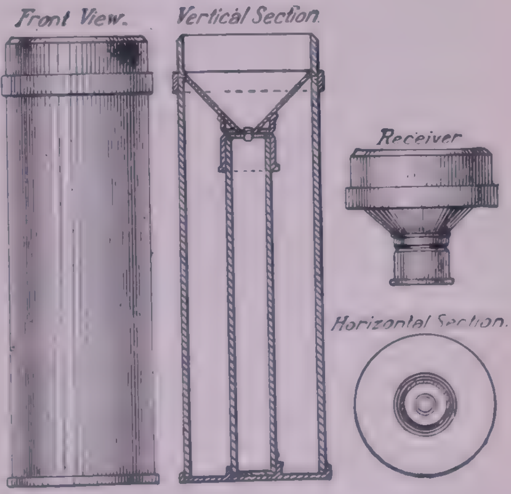

Fig. 201. — Rain gauge

When the reports of the weather made by the observers in various parts of the country have been received at Washington and other cities, the figures are put down in their proper places on a blank map of the

United States; from these a weather map like that shown in figure 195 is constructed.

WEATHER FORECASTS

This map when completed gives a general view of the weather conditions for the day throughout the whole country. Having made this map, how are the weather forecasters able to foretell what the weather for a certain place will be on the following day? A study of a great many maps for many years has shown that after a low area has formed in the western part of the country, it moves across the country in an easterly direction at the rate of several hundred miles a day. This speed varies according to season, averaging about nine hundred miles a day in winter and about 525 miles in summer. In a similar way the high areas move in an easterly direction. The weather experts are able to prophesy about how far the areas will travel by the next day, and hence what weather conditions will be brought to the various localities. Forecasters for a given city have also learned that the weather may be affected by certain local features of land and water.

To put it in another way, if one wishes to ascertain the weather conditions that he will find in his locality at the end of twenty-four hours, he can look at the weather conditions found in the area situated as far west of his locality as a low area travels in one day.

These maps are made not only at Washington but in many other large cities and, with the forecast printed on them, are sent into the surrounding sections of the country. A brief forecast is given to the daily newspapers.

These forecasts are right in from 85 to 90 per cent of the predictions — that is, on six days out of seven — and constitute the most reliable method of foretelling weather. Sometimes forecasts are made for two days ahead; but the longer ahead the forecast is made, the more unreliable it is, because the low areas undergo so many changes as they pass across the country that it is possible to foretell for only a short time what the weather changes will be.

Laboratory Exercise 13

Purpose. To keep a record of weather conditions by means of instruments.

Materials. Barometer; ordinary thermometer; maximum and minimum thermometer; weather vane.

Directions. 1. Copy in your notebook the following table. Between eight and nine o'clock each morning make the observations called for and put the record in your notebook.

DATE	HOUR	PRESSURE	TEMPERATURE			CLOUDS (Amount in Tenths)	PRECIPITATION	WINDS	
			Current	Maximum	Minimum			Direction	Force

The record of the force of the wind may be kept in accordance with the following scale proposed by the United States Weather Bureau: 0, calm; 1, light, just moving the leaves of trees; 2, moderate, moving branches; 3, brisk, swaying branches, blowing up dust; 4, high, swaying whole trees, blowing up twigs from the ground; 5, gale, breaking small branches, blowing loose bricks from chimneys; 6, hurricane, or tornado, destroying everything in its path.

2. It may be well to have the class divided into sections and allow each section to keep the records for a certain time, so that all together may keep the record for a large part of the school year.

3. After the records have been kept for a month or longer, study them to see if you find any relation between (*a*) pressure and temperature, (*b*) pressure and precipitation, (*c*) pressure and direction of wind, (*d*) pressure and cloudiness, (*e*) precipitation and direction of winds, (*f*) temperature and direction of winds.

Laboratory Exercise 14

Purpose. To learn how one may foretell the weather by a study of weather maps.

Materials. Series of successive weather maps.

Directions. 1. Find each of the following on the map and explain what it signifies: (*a*) the continuous black lines; (*b*) the dotted black lines; (*c*) the circles; (*d*) the arrows attached to the circles; (*e*) the shaded areas; (*f*) the words "high" and "low."

2. On the map find the place that had (*a*) the highest temperature, (*b*) the lowest temperature, (*c*) the greatest air pressure, (*d*) the least air pressure. In the columns find the place that had (*a*) the highest maximum temperature, (*b*) the lowest minimum temperature, (*c*) the highest wind velocity, (*d*) the greatest rainfall. In each case give figures and name of place.

3. State all the weather conditions shown on the map for your own city or the nearest Weather Bureau station.

4. Compare a number of high and low areas on different maps and explain how the highs differ from the lows in (*a*) pressure, (*b*) direction of winds, (*c*) temperature, (*d*) state of weather (rainy or clear).

5. Follow the course of a low area on several successive maps and estimate (*a*) about how far the area travels in a day and (*b*) in what direction.

6. Secure the latest weather map and prophesy what you think the weather will be for your locality for the next day. When the time comes, make a note of the actual conditions and see how close your predictions were.

OUTLINE SUMMARY

Weather Forecasting

- I. The temperature
    - 1. Effect of air
    - 2. Change of seasons
    - 3. Factors affecting temperature
    - 4. Range of temperature
- II. Moisture in the air
    - 1. Evaporation
    - 2. Precipitation
        - *a*. Dew and frost
- III. Winds

- IV. United States Weather Bureau
- V. Uses of weather forecasts
    - 1. Value to fruit growers
    - 2. Protection of ships
    - 3. Protection from floods
- VI. Description of weather map
    - 1. How figures are obtained
- VII. Weather instruments
    - 1. Barometer
        - *a*. Torricelli's experiment
        - *b*. Construction of barometer
        - *c*. Principle of barometer
        - *d*. Uses
            - (1) In weather predictions
            - (2) For measuring heights
                - (*a*) Aneroid barometer
    - 2. Thermometer
    - 3. Rain gauge
- VIII. Weather forecasts

QUESTIONS FOR CLASS DISCUSSION

1. To what people are the weather forecasts of the Weather Bureau of greatest value?
2. What does a weather map show?
3. How is a weather map made?
4. What factors determine the climate of a city?

REFERENCES

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Salisbury, Barrows, and Tower, *Elements of Geography*. Henry Holt and Co., New York.

R. B. A. N. M'S EDUCATIONAL CHARITIES.
No.……………………
Date.……………………
BANGALORE.

CHAPTER XXXI

THE LAND SURFACE

In what ways do the forms of the land surface and the forces acting thereon affect man?

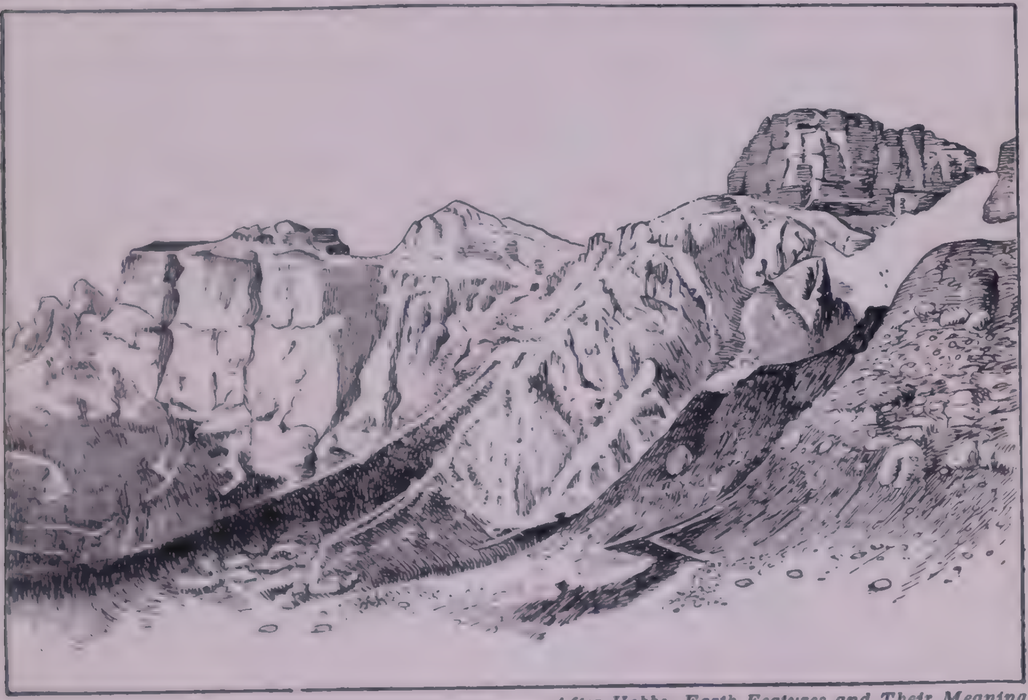
The Forms of the Land Surface

The conspicuous forms of land and water that attract our attention as we travel about may be roughly classified into two groups: the larger features and the smaller features. Among the larger features are included mountains, plateaus, and plains; among the smaller features, hills, valleys, and lakes.

The variation in these features on different parts of the earth gives a zest to travel because of the beautiful landscapes. A large part of the pleasure of travel and vacations comes from a change in our surroundings. If we live on the plains, we enjoy going to the mountains for a vacation. If we live inland, we enjoy going to the seashore. And even in those sections where we live most of the time, we derive pleasure from the scenery that surrounds us.

In still another way these forms of the earth's surface have a very important effect in shaping man's life. The early development of a country depends very largely on these physical features of the earth's surface. Men naturally settle along rivers which furnish fertile plains for farming and easy means of transportation by boat. The locations of large cities are determined largely by physical features of the earth's surface. On the other hand certain features, such as high, rugged mountains, interfere with settlement and act as barriers to development. The study of geography everywhere emphasizes the great influence that the various features of the land surface have had on man.

The larger features. *Mountains.* Sometimes elevations that are locally known as mountains are considered hills by the geographer. Real mountains are defined as land masses that rise conspicuously above the surroundings and have small areas on the summit, sometimes only a peak and sometimes a long narrow ridge. They may vary in height from a few hundred feet to thousands of feet. High, rugged mountains rising abruptly above their surroundings furnish the most awe-inspiring scenery on the earth.



After Hobbs, Earth Features and Their Meaning

Fig. 202. — Mountains of the block type, in Tyrol

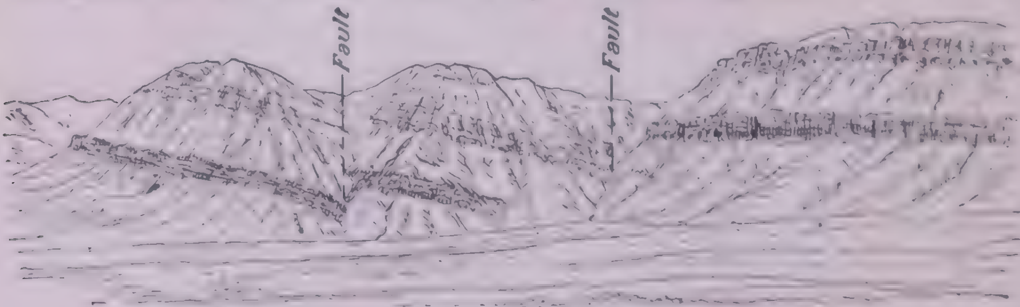
As one ascends a high mountain a very marked change in climate occurs, from a mild temperature at the base to a frigid climate at the summit, some mountains being capped with snow during the entire year. On the average the temperature decreases one degree for every 330 feet that one ascends.

How mountains were formed. When seeking an explanation of how mountains have been formed, we notice first the fact that the interior of the earth is intensely hot, as shown by deep mines and volcanoes. Scientists believe that the interior of the earth is solid. While the temperature here is high enough to melt rocks, these are kept solid because of the great pressure on them. Under certain conditions the pressure may be removed over small areas, and then the rocks melt and pour forth in volcanic eruptions.

It is believed that the earth's interior is cooling slowly and hence shrinking. Therefore the earth's crust forms huge wrinkles, much like those in the skin of a drying apple. These wrinkles are mountains. The process is a very slow one, and the time required for a mountain to form must probably be reckoned in millions of years. The process of mountain formation is going on at the present time, only so slowly that we cannot see any change.

Types of mountains. Several types of mountains are distinguished, according to their appearance and the way in which they have been formed. *Folded* mountains have been formed by the folding and uplifting of rocks that had begun to form on the ocean's bottom. When these were uplifted, the rocks were bent into folds.

A *block* mountain is one in which a great break or fault occurred in the rocks while they were being uplifted. Great

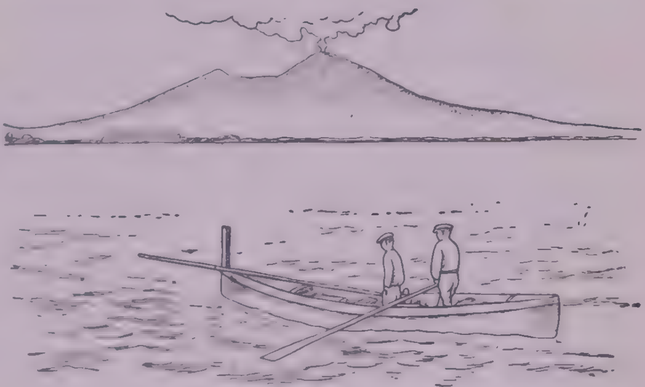


After Hobbs, Earth Features and Their Meaning

Fig. 203. — Tilted crust blocks

sections of rocks slipped over one another at this joint. Usually one side of this type of mountain is very steep, while the slope on the other side is gentle.

Volcanic cones form another type of mountain. These have been made by the accumulation of lava and small pieces of rock around an opening in the earth's crust, through which the rock from the interior has been forced out.



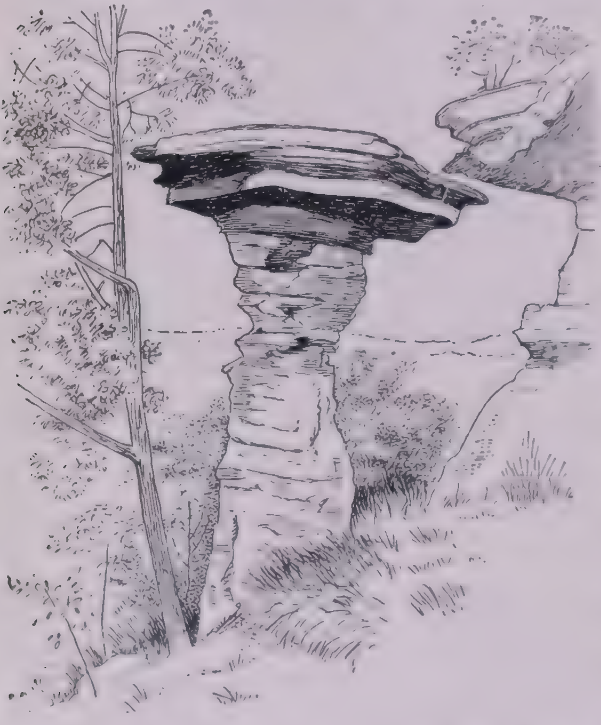
After Hobbs, Earth Features and Their Meaning

Fig. 204. — Mount Vesuvius from the Bay of Naples, shortly before the eruption of 1906

Still another type is known as a mountain of *unequal erosion.* After a great section of the earth's crust has been lifted up, the rivers and other agents of erosion begin to cut it down. Since some rocks are harder than others, they resist the action longer and hence stand up as mountains after the softer parts between have been worn away.

The Jura Mountains in Europe are an example of folded mountains; the Wasatch Mountains in Utah, of the block mountains; Mt. Hood in Oregon, of the volcanic mountain; and Mt. Mitchell in the Appalachian Mountains, of the mountain of unequal erosion.

Plains and plateaus. Plains and plateaus are similar in that both are smooth areas of land. Usually, but not always, plateaus are higher than plains. Plains are very favorable for settlement. These were the portions of our country first settled in the early days. More than nine tenths of the people of the United States live at elevations of less than fifteen hundred feet, and more than one third at elevations less than five hundred feet. Different types of plains are named according to their method of formation. Coastal Plains are found along the coast; Flood Plains are found along rivers; Lake Plains are the floors of extinct lakes, such as the valley of the Red River of the North; Glacial Plains, formed by former glaciers, are found in the north central states.



After Tarr and Martin, College Physiography

Fig. 205. — Stand Rock, Wisconsin

The smaller features of the earth's surface. We have been studying briefly the large features, such as mountains and plains, and the method of their formation. We now come to a consideration of the smaller features, such as hills, valleys, and lakes. In general these minor features have been formed through a different set of agencies, which act more quickly than those that form mountains. Two groups of forces are acting on the earth's surface, one group building it up and the other wearing it down. In general, the effect of the internal forces acting from the earth's interior is to build up the land, while the effect of the external forces, such as streams and glaciers, is to wear it down. While this is the general total effect, it is not always true in every detail, because streams wear down in one part of their course and build up in others.

We will now turn to a consideration of those forces that carve out the minor features, such as the hills and the valleys. Following are the forces chiefly concerned with this work: streams, glaciers, waves, and wind. These might well be called Nature's sculptors.

FORCES AT WORK ON THE LAND SURFACE

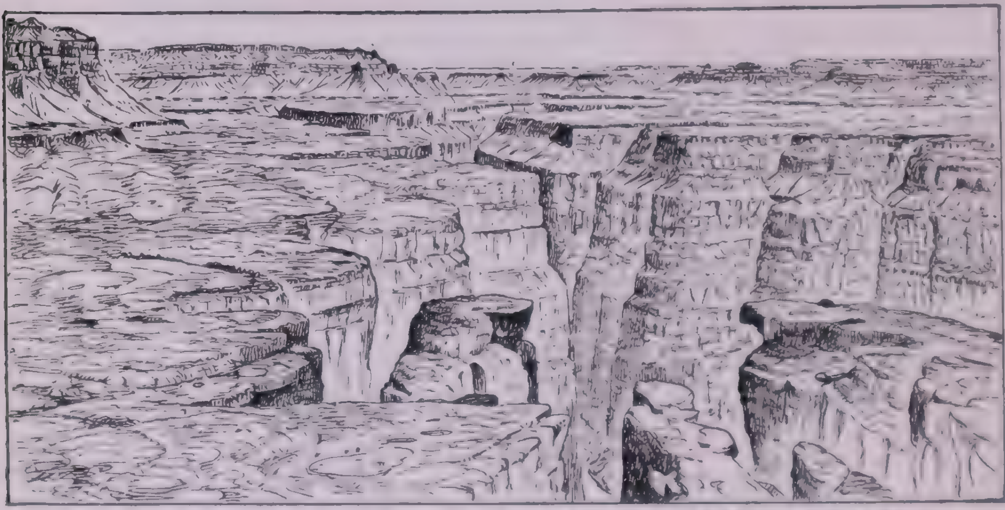
Rivers. Rivers are useful to man in many ways: as highways for navigation, as sources of power, as sources of water for irrigation, as sources of food fish, as sources of water for city uses, and as a means of recreation. Around the mouths and along the banks of rivers are clustered many cities and towns. In the development of this country and in times of war, rivers have played an important part. Outside of their importance to man, rivers perform many functions in nature, the chief one being to remove the surplus rainfall. While doing this, streams are wearing away the land over which they flow and are producing conspicuous changes, slowly but nevertheless surely.

The work of a river may be divided into three parts: (1) transportation, or moving loose materials to lower levels; (2) corrasion, or wearing down its channel; (3) deposition, or dropping its load. The term erosion is used to mean the general wearing away of the land — including corrasion and transportation, mentioned above, and also weathering, a process of breaking up rocks that will be discussed a few pages later on.

Transportation. Rivers carry materials in three ways: in solution; by rolling them along the bottom of the stream; and by holding them up like floating bodies while they are entirely under water. The transporting power of a stream depends chiefly on its velocity and its volume. When an object is placed under water it loses weight; sediments and rocks, for instance, lose about one third of their weight. A slight change in velocity makes a large difference in the transporting power of a stream, since this power varies as the sixth power of the velocity. For example, if the velocity is doubled, the transporting power is increased sixty-four times.

The total amount of sediment thus carried by rivers is enormous. The Mississippi River carries daily, on the average, more than a million tons of sediment into the Gulf of Mexico. It is estimated that during a year the Missouri River carries more mile-tons of sediment than the railroads of the United States carry mile-tons of freight.

Corrasion. As a river flows over its bed, it wears the rock away. Pure water acts very slowly, but the sediment that a river carries acts as a tool by means of which the rock beneath is gradually scoured away. At the same time the particles of sediment become rounded. The river cuts its valley both downward and from side to side. In the early stages the downward cutting predominates; and deep cañons are sometimes formed, as the great cañon of the Colorado River. In the later stages after the river has cut *down* deeply, it tends to wear its bed more from *side to side* and thus to widen its valley. As the river flows in curves, these curves tend to increase till only



After Tarr and Martin, College Physiography

Fig. 206. — Cliffs and slopes in the Colorado Cañon

a narrow neck of land separates the parts of the stream. Then the river may straighten out again by cutting across this narrow neck of land, and the former bed may be left as an ox-bow cut-off. Illustrations of winding streams and of cut-offs are common in those streams that have broad flood plains.

The rate at which the land is being cut down varies in different parts of the United States. It has been calculated that it varies from one inch in about 440 years in the Colorado basin to one inch in about 3,900 years in the basin of the Red River of the North, the average for the United States being an inch in about 760 years.

Deposition. We have already seen that the carrying power of a river depends on two factors — velocity and volume. If either one of these factors is lessened, then the carrying power is decreased, and a portion of the load is deposited. The most common cause for deposition is the lessening of the velocity of a stream. When a river flows into a lake or sea, the velocity is checked and the river deposits its load in formations known as deltas. When the velocity is checked, naturally the largest sediments will be deposited first; and then, if the velocity is further checked, the next largest sediments; and so on till all the sediment is deposited in the ocean or lake. Hence we see that the materials are sorted according to size and are stratified — that is, arranged in layers.

Another condition that checks the velocity of a stream is the abrupt change in slope when a stream flows from a hilly section to the land of a comparatively flat country and sinks into the soil or evaporates. Under these conditions deposits are made in *alluvial fans*, which are common in the western United States.

Another very common condition that brings about deposition is the rising of rivers in the spring, when they overflow their banks. When the rivers overflow, sediment is deposited on the flood plains, more sediment being deposited near the river bank than farther away. As a result a natural levee is built up along the edge of the river.

Thus, looking at the entire work of a river, we see that its tendency is to wear down the land to a level plain and deposit the materials in the sea. If time enough were allowed and nothing else interfered, the land would all be worn down to a level, gently sloping plain; but at the same time other forces that tend to uplift the surface of the land are also acting, so that the final forms of land we find at any time are the resultant of the actions of these two sets of forces.

On the whole the work of the streams in causing erosion is harmful to man for the following reasons: (1) Much valuable soil is washed away; (2) the material may be deposited on farm lands in such a way as to do harm; (3) deposition in rivers may interfere with navigation. We have already seen in Chapter XXIX that one way to prevent soil erosion is to raise forests on steep slopes.

FIELD EXERCISE 11

Purpose. To study the action of rivers.

Directions. 1. After a heavy storm go to some steep hillside and look for action of the small streams that formed during the storm. Notice the size of the largest pebbles moved.

2. Fill a large glass jar with water taken from the river and allow it to stand for several days. Notice the sediment that is deposited.

3. If possible, go to the mouth of a stream where it empties into a lake or another stream. Notice the delta. What is its shape? Of what materials is it composed? Are the pebbles rounded or do they have sharp corners? Notice the character of the deposits along the edge of the river bank.

4. If you can find a small, winding stream, study its action. On which side of the curve is the stream wearing away its bank? What is happening on the other side of the curve? Can you find an ox-bow cut-off? If so, notice its relation to the present course of the stream.

Glaciers. While at the present time glaciers are a very minor factor in modifying the earth's surface, yet thousands of years ago Canada and the northern part of the United States were covered by a huge glacier, the effects of which are still felt today. Like a river, a glacier transports, corrades, and deposits. Also like a river, it cannot corrade much without the aid of rocks. With these frozen into its mass, it scours rocks beneath it; and today we still find rocks covered with the scratches made by the glacier thousands of years ago.

In the process of transportation rocks may be carried on the surface of the glacier, may be pushed along beneath the glacier, or, after falling from the surface into cracks, may be carried along within the main mass of the ice. The effect of this old glacier is still felt through its deposits. A large part of the soil now used in those sections of the country formerly covered by glaciers was brought there by the glaciers from regions farther north. The southern limit of these deposits is well marked by a series of irregular hills, known as the terminal moraine. This begins in Long Island, extends in a general southwesterly direction to southern Illinois, and from here extends in a northwesterly direction to the northern part of Montana, and then westerly to the Pacific coast, in Washington.

One result of this glacier is the large number of lakes found in this section of the country, most of which are of glacial origin. These lakes were formed in a variety of ways. Some were formed in basins scooped out of solid rock; some in hollows in the surface of the drift; and some in basins formed by the terminal moraines, which acted as dams across the streams. Some huge glacial lakes have disappeared, and fertile plains are now found where their bottoms formerly existed, as along the Red River of the North, which was the site of glacial Lake Agassiz.

As geology reckons time, lakes are short-lived. The stream that forms the outlet tends to drain the lake by cutting a deeper channel. Streams which flow into the lake tend to fill it up by the deposits that they bring in. This process is still further aided by plant growth. Thus lakes gradually change to swamps.

FIELD EXERCISE 12

Purpose. To study the results of glacial action.

Directions. 1. If you live in the northern part of the country, over which glaciers formerly passed, study the surface of solid rock exposures for the scratches made by glaciers. Look over the deposits in some railroad cut to see if you can find scratched boulders.

2. To study glacial deposits go to some location where a section is cut through the deposits, as in a railway cut or a bank beside a stream. How are the materials arranged — are they stratified or unstratified? Are the materials of one size sorted out together or are they mixed? Are the pebbles rounded or do they have sharp corners?

3. Make a collection of as many different kinds of rocks and minerals as you can find in these glacial deposits.

4. What is the general surface appearance of the glacial moraines around your home — level or hilly? If hilly, are the hills large or small? Are they rounded or steep?

The wind. The effect of the wind as an agent of erosion is limited largely to dry regions or to coast regions where masses of dry sand are exposed. In sections where there is an abundant growth of vegetation, wind has little influence. Wind, like rivers, may transport, wear away, and deposit. There is a certain amount of small dust particles in the air in nearly all parts of the world, and these may be blown for thousands of miles. But the most noticeable effects of wind are seen in sections where dry sand exists. The most conspicuous deposits of the wind are sand dunes. These are hills of sand, usually steep on the leeward side and gently sloping on the windward side. These dunes often migrate from place to place, following the direction of the prevailing winds. Sometimes they do harm by completely burying forests and even buildings. In order to stop this motion, sometimes certain kinds of sand grasses are planted on the surface of the sand dunes.

These dune formations have a unique appearance and are objects interesting to visit, like mountains and lakes. On the southern shores of Lake Michigan is an interesting group of dunes, and it has been suggested that these should be set aside as a national park and thus preserved for their beauty and strangeness.

THE EARTH'S ROCK COVERING

Bed rock. The rock found on the earth's surface may be divided into two groups: the bed, or solid rock, and the mantle, or loose rock. Since the loose rock was derived from the solid rock, we will first notice the kinds and the structure of the bed rocks.

Minerals. Rocks are composed of substances known as minerals. These minerals originally were formed in definite shapes called crystals. These crystals differ in form, in color, in hardness (that is, the ease with which they are scratched), in luster, and in cleavage (the ease with which they split into pieces).

Rock-forming minerals. While there are several hundred kinds of minerals, most of the rocks are made up of various combinations of seven or eight of these. Brief mention is made of a few of the most common.

Quartz is the most abundant of all the minerals. It is also the hardest of the common minerals, being so hard that it easily scratches glass. In its purest forms it is transparent and its crystals are in the shape of six-sided prisms capped with pyramids. As commonly found in sands and sandstone, it has lost its crystalline shape and is usually mixed with other substances which give it a variety of colors. Onyx, agates, and opals are forms of quartz.

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Another common mineral is calcite, which is easily distinguished from quartz by the following characteristics: It is so soft that it can easily be scratched with a knife; when acid is poured on it, bubbling takes place, due to the escape of the gas, carbon dioxide; and the crystals tend to split in three planes, giving the shape of a rhomb, which looks like a cube with the angles pushed out of square.

Feldspar is similar to calcite in appearance but is much harder and does not bubble with acids. Its most common colors are white and pink. It is found in granite.

Mica is the mineral sometimes called isinglass. Its chief feature is the ease with which it splits into thin, lustrous plates. On account of its ability to withstand high temperatures, it is often used in stove doors. It is used also in electrical work because it is an insulator.

Mineral ores. There is another group of minerals, known as ores, which are of importance because they are the source of some important metals. For example, iron is obtained from the two minerals, magnetite and hematite; lead, from galena; zinc, from sphalerite; aluminum, from bauxite; quicksilver, from cinnabar; and copper, gold, and silver are found in their native state mixed with other substances.

Other useful minerals are salt, corundum (used, for its hardness, in making grinding-disks), borax, several fertilizers, asbestos minerals (used for the fireproof qualities of the asbestos), graphite (used for making lead pencils), and mineral pigments (used for giving color to paints).

And finally there is a group of minerals that are so valuable for purposes of ornamentation that they are called gems and precious stones. Among these are diamonds, rubies, sapphires, emeralds, garnets, and opals.

Two other very important products obtained from the interior of the earth are coal and petroleum.

Kinds of rock. Rocks are divided into three groups: igneous, sedimentary, and metamorphic. Igneous rocks have been formed through the cooling of heated molten rock. Sedimentary rocks have been formed through the union of fragments of other rocks, which have generally been laid down in water. The beginnings of this process may be seen at the mouth of any stream where sediments are brought down and deposited in some lake or ocean. The mouths of rivers that empty into the oceans are the locations where this process is now taking place on a huge scale. Later these sediments are bound together into solid rock. Another kind of sedimentary rock is that formed from the skeletons of corals and various kinds of shellfish, which later form limestones. Metamorphic rocks are formed from other solid rocks, the chief factors that produce the change being heat, pressure, and moisture.

In their appearance these classes of rocks differ in three respects: their stratification, their crystalline character, and the minerals of which they are composed. The following table shows the first two differences:

IGNEOUS	SEDIMENTARY	METAMORPHIC
Crystalline	Not crystalline	Crystalline
Not stratified	Stratified	Stratified

A few of the more common rocks found in each group are shown in the following table:

IGNEOUS	SEDIMENTARY	METAMORPHIC
Granite	Sandstone	Marble
Basalt	Limestone	Slate
	Conglomerate	Gneiss
	Shale	Mica schist
		Quartzite

Rocks differ also in the minerals of which they are composed, as is shown for a few rocks in the following table:

NAME OF ROCK	MINERALS OF WHICH COMPOSED
Sandstone	Quartz
Quartzite	Quartz
Limestone	Calcite
Marble	Calcite
Granite	Quartz, mica, feldspar
Gneiss	" " "
Mica schist	" "

The relation between the loose rock and the various kinds of solid rock, showing how they may slowly change from one to another, is indicated in the following table. Those in the first column change to those in the second through consolidation, and those in the second column change into those in the third column through metamorphism.

MANTLE ROCK	SEDIMENTARY ROCK	METAMORPHIC ROCK
Clay	Shale	Slate, mica schist
Sand	Sandstone	Quartzite
Marl, shell beds	Limestone	Marble

SCHOOL PROJECT 6

Purpose. To make a collection of rocks and minerals.

Directions. 1. The class may work together to make a school collection of the rocks and minerals found in the vicinity. Some cabinet or shelf may be arranged for keeping the specimens.

2. Bring all the different kinds of specimens you can find. Secure uniform cardboard labels, and write on each label the name of the specimen and the name of the person who brought it in. On the label write also the name of the group to which the rock belongs, as explained on page 537.

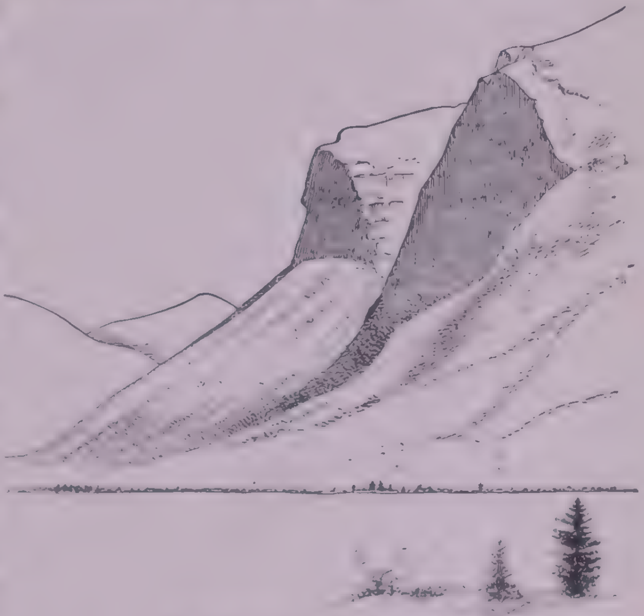
3. After a number of specimens have been collected, compare the different rocks. Are they stratified or unstratified? Are they composed of crystalline substances or uncrystalline? Are the materials in the rocks

rounded or angular? What kinds of minerals do you find in each kind of rock? Try the effect of some acid, such as hydrochloric acid, on each kind.

4. Study the minerals to note how they differ in hardness (try to scratch with a knife), color, shape of crystals, cleavage, luster, and reaction with acids.

Mantle rock. The loose rock-material that covers most of the surface of the land may vary in thickness from a few inches to several hundred feet. The most common kinds of material found in this mantle rock are sand, clay, and gravel. This mantle rock is vitally important to man for several reasons. In the first place, at the top of this is the soil that makes agriculture possible. As a great storehouse of water, it helps to prevent floods. As a distributor of water, it furnishes the water and the plant food necessary to the growth of plants. It also furnishes some of our drinking water and acts as a filter to purify it.

Weathering. Let us next turn our attention to the method by which this mantle rock is formed. The original rock is the bed rock, which we have already studied; and the mantle rock is formed from the bed rock, partly through the action of glaciers and running streams, but chiefly through a process known as weathering. The chief agents that produce weathering are the following: oxygen, carbon dioxide, plants, animals, water, frost, and change in temperature.



After Hobbs, Earth Features and Their Meaning

Fig. 207. — Talus slope beneath a cliff

Oxygen, which makes up about one fifth of the air, is a very active element and acts on some parts of the rocks, causing them to break up. One substance frequently thus oxidized is iron, and the yellowish color so often seen in soils is due to compounds of iron.

Water may dissolve certain substances directly; and when it contains carbon dioxide in solution, it may also affect other rocks, such as limestone. When certain portions of the rock are removed, the remainder of the rock crumbles.

In northern climates frost is a factor in weathering. When water freezes, it expands with great force. Thus the water that finds its way into porous rocks and into cracks tends to pry off small particles of rocks as it freezes and expands.

The effect of change of temperature is most marked in those regions where there is a conspicuous difference between the temperatures of the night and the day. During the day as the rocks become heated, they expand; and during the night as the rocks cool, they contract. This slight motion has a tendency to loosen portions of the rocks.

Some plants and animals aid in the process of weathering. One kind of plant, called lichen, grows on the bare surface of rocks and gives out chemicals which act on the rocks. Roots of plants often find their way into cracks in the rocks and, as they grow, exert a great pressure. Some animals live in the soil and, by working it over, aid the process of weathering. The most valuable animals in this connection are the earthworms.

FIELD EXERCISE 13

Purpose. To study the process of weathering.

Directions. 1. See how many different agents of weathering you can find at work. Notice the effect of each agent.

2. What evidences of the action of animals can you find? Notice the castings brought up by earthworms; the little hills made by ants.

3. Look for the action of plants. Can you find any lichens growing

on the bare surfaces of rocks? Can you find roots of plants growing in the cracks of rocks?

4. Can you find any evidence of the action of frost through the freezing of water in cracks?

5. Look for evidence of the action of oxygen, carbon dioxide, and water. Do you find yellowish and brownish materials among the soils? If so, this is an evidence of the action of oxygen on the iron in the rocks.

6. To show the action of water and carbon dioxide, take some water from a well or spring and evaporate it. Do you find any deposit left?

7. Are the soils in your vicinity residual or transported? (See page 541.) See if you can find an illustration of a residual soil exposed in some cutting. As you pass from the top soil down to the bed rock, what change in the material occurs?

Soils. Nearly all that we eat and wear comes directly or indirectly from the soil. In many cases we eat vegetable foods grown directly in the soil. When we eat animal food we are indebted to the soil, since most of the animals in turn feed upon plant food grown in the soil. Likewise with our clothing: Two materials (cotton and linen) come directly from plant products, while two (wool and silk) come from animals which feed upon plants grown in the soil.

While the mantle rock in places may be several hundred feet in depth, the word soil is usually applied to the top portion, the part just beneath this being called the *subsoil*. The various soils are classified into two groups: *residual* and *transported*. Residual soils are those formed from the decay of the rocks directly beneath. Transported soils are those that have been brought from some other locality by such agencies as water, glaciers, and wind. Most of the soils of the northern states, called *drift* or *glacial soils*, are of the transported type, brought there long ago by glaciers. Soils that have been brought and deposited by rivers, as in flood plains and deltas, are called *alluvial* soils.

Ingredients. The ingredients of an agricultural soil in which plants will grow are four: sand, silt, clay, and humus. The first three come from the decay of the bed rock, the last comes from the decay of plant and animal life. It is necessary also that bacteria be present in soil if plants are to grow. The chief difference between sand, silt, and clay is one of size, as shown in the following table:

MATERIAL	SIZE
Sand	1/50 to 1/500 inch
Silt	1/500 to 1/5,000 inch
Clay	Smaller than 1/6,000 inch

Types of soils. Soil composed entirely of any one of these materials would not be fertile. Practically all agricultural soils contain some of each of these three materials, the proportion varying for different soils. A loam is a soil that contains a fair proportion of all three. A sandy soil contains a large proportion of sand, while a clayey soil contains a large proportion of clay.

Soils possess different characteristics according to the proportions of sand and clay present. Sandy soils are porous and hence well drained. They are classed as warm or early soils, and they dry out quickly in times of drought. On the other hand, clayey soils are usually poorly drained, and plants growing in them do poorly in wet seasons. They are classed as cold or wet soils. They do not suffer from drought as much as sandy soils.

DEMONSTRATION 58

Purpose. Of what is an ordinary soil composed?

Material. Wide-mouthed bottle; soil.

Directions. 1. Put in a wide-mouthed bottle about an inch of ordinary soil.

2. Fill the bottle about three fourths full of water. Cork the bottle and shake it vigorously.

3. Allow it to stand for a day; then notice the way the soil is arranged on the bottom of the bottle. Do you find anything floating on the surface?

4. What kinds of material are shown by this experiment to be present in the soil?

Not only must soils furnish roots with water, but they must also provide roots with air. There is a close relation between the water capacity and the air capacity of soils. A clayey soil, which has great water capacity, may shut out the air because the water occupies air spaces between the soil particles. On the other hand, a sandy soil with less water capacity furnishes more air spaces because the water drains off.

The humus in soils serves several very important purposes, among them the two following: It increases the water capacity of the soil, and it furnishes plant food.

Care of soils. The proper care of soils consists chiefly in three activities: (1) plowing and harrowing, (2) cultivating, and (3) fertilizing. Cultivation keeps down the weeds; and it mixes air with the soil. Water rises through the spaces between the soil particles by a process called capillarity (see page 58) till it reaches the upper portion of the soil, from which it is absorbed by the roots of plants.

DEMONSTRATION 59

Purpose. To show how water comes up through soils for plants to use.

Materials. Several wide-mouthed bottles; piece of cheesecloth; pan; and as many of the following kinds of soil as you can secure: ordinary garden soil; sand; clay; leaf mold from under a growth of trees.

Directions. 1. Fill each of the bottles with one of the kinds of soil you have collected.

2. Over the mouth of each bottle tie a piece of cloth.

3. Invert the bottles in a pan containing about an inch of water.

4. Allow to stand for several days. Notice (*a*) in which kind of soil the water comes up the quickest, and (*b*) in which kind the water first reaches the top of the soil in the bottle.

Fertilizing is necessary in order to put back into the soil certain elements that are taken out by the growing crops. Of the seven or eight elements that plants take from the soil, some are present in the soil in such quantities that they will last almost indefinitely, while other elements are so limited that the supply is soon exhausted and hence some must be put back in the form of fertilizers.

The three chief elements that must be replaced are nitrogen, phosphorus, and potassium. These may be put back in two ways: (1) by using manure, and (2) by adding commercial fertilizers, such as sodium nitrate, phosphates, and potash; and the nitrogen may be put back also by growing leguminous crops and plowing them under. Although the air contains a large amount of nitrogen, plants cannot make use of it in the form in which it exists there. It has been found, however, that when certain plants called legumes — such as clovers, alfalfa, peas, and beans — grow in a soil, little lumps form on the roots, and in these are found bacteria that take nitrogen from the air and make it into a compound that can be used by plants. Hence one of the best ways to add nitrogen to the soil is to grow legumes.

The farmer must also add humus to the soils. This may be done in either one of the two ways mentioned above: that is, by using manure or by growing crops and plowing them under. The advantage of the first method is that it adds also the three elements, nitrogen, phosphorus, and potassium, while the last method adds only nitrogen.

When new land is first used for farming, it is possible to raise crops for a number of years without adding fertilizers; but eventually the farmer must put back on the land some of the minerals that the plants have removed from it. Dairying is valuable in modern farming, not only for such products as milk and meat, but also for the manure which can be put back on the land as fertilizer.

OUTLINE SUMMARY

The Surface of the Land

- I. The forms of the land surface
  - 1. The larger features
    - *a*. Mountains
      - (1) How mountains were formed
      - (2) Types of mountains
    - *b*. Plains and plateaus
  - 2. The smaller features
- II. Forces at work on the land surface
  - 1. The work of rivers
    - *a*. Transportation
    - *b*. Corrasion
    - *c*. Deposition
  - 2. Glaciers
  - 3. The wind
- III. The earth's rock covering
  - 1. Bed rock
    - *a*. Minerals
      - (1) Rock-forming minerals
      - (2) Mineral ores
    - *b*. Kinds of rock
  - 2. Mantle rock
    - *a*. Weathering
    - *b*. Soils
      - (1) Ingredients
      - (2) Types of soils
      - (3) Care of soils

QUESTIONS FOR CLASS DISCUSSION

1. How has the development of our country been influenced by the forms of the land surface?

2. How has the development of your home city been influenced by the same factors?

3. What are the chief differences between the way the larger features have been formed and the way the smaller features have been formed?

4. What forces are tending to build up the earth's surface? What forces tend to wear it down?

5. In what ways are the actions of a river and a glacier similar? In what ways different?

6. Which is more important to man, the bed rock or the mantle rock? Why?

7. Which is a better soil, a sandy soil or a clayey soil?

8. What is the value of changing the crops grown on a certain area in different years?

9. Why is dairying a specially valuable type of farming from the standpoint of soils?

10. What will be the result if no form of fertilizer is put back on the land?

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CHAPTER XXXII

THE EARTH'S NEIGHBORS IN SPACE

1. In what ways are the sun and the moon different?
2. How do stars differ from planets?

THE SOLAR SYSTEM

The earth is but one of many heavenly bodies scattered through space. In this chapter we will try to obtain some idea of these bodies and of their relation to the earth. The earth, the other planets, the moon, and the sun are included together in the solar system. The center of this system is the sun; revolving around this sun are the planets, situated at varying distances from the center. Some of these, such as Mercury and Venus, are nearer the sun than is the earth; others, such as Mars, Saturn, Uranus, and Neptune, are farther away than the earth.

The positions of these planets may be illustrated by means of circles, as shown in figure 208. The dot in the center represents the sun; the circles represent the orbits of the various planets. If one inch be taken to represent the distance of the earth from the sun, then to represent the orbit of the moon a circle should be drawn around the earth at a distance of one four-hundredth of an inch from it. This is too small to be shown on this diagram. All these bodies of the solar system — the planets, the moon, and the sun — form a single group and are relatively very close together, compared with the distance from the stars. If we were to make a dot to represent the position of the nearest star on the same scale, it would be located almost four miles away.

Changes in the solar system. All the bodies of the solar system are going through a series of changes. At one time probably all were intensely hot. The sun is in that stage now, and possibly the major planets. The earth represents a later stage in which the crust is cool but the interior is hot, as shown by volcanoes. The moon represents a still later stage, for it has lost nearly all its heat and is probably cooled all the way through.

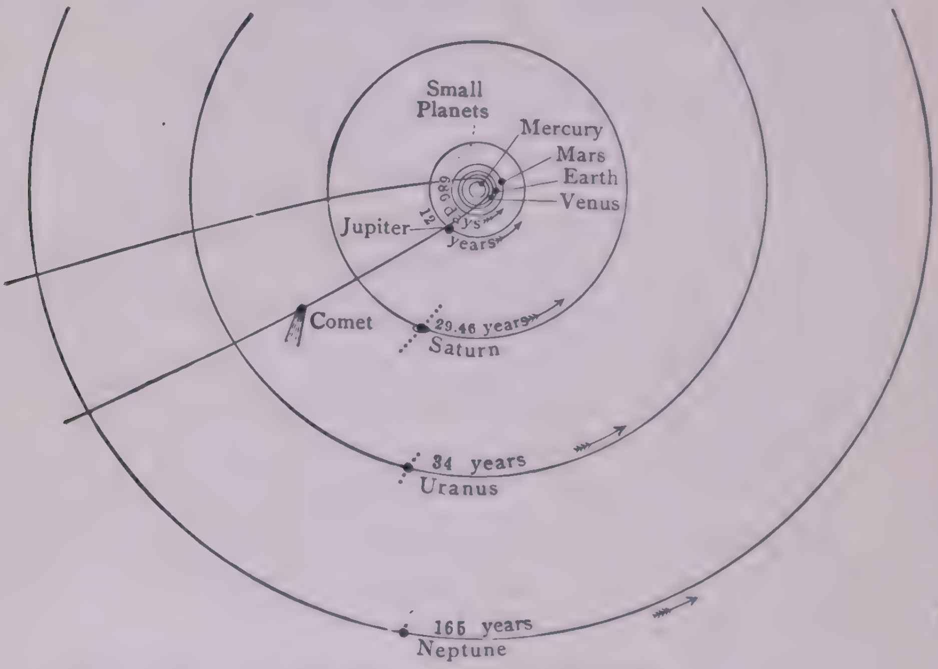

Fig. 208. — The solar system

The relative distance of each planet from the sun; the number of each planet's satellites; the relative size of its orbit; the period of its revolution about the sun.

Relative distances of heavenly bodies. Hold the hand with the fingers spread so that the tip of the third finger is about six inches from the thumb. Let the thumb represent the sun, and let the four fingers represent the position of the first four planets, Mercury, Venus, Earth, and Mars. Then, proportionately, the nearest star would be at a distance of almost twenty-five miles, and the North Star would be at a distance of over two hundred and fifty miles, while the most distant stars would be at a distance greater than the entire width of the United States from New York to San Francisco. This statement illustrates the fact that while the distances between the earth and the sun seem large as compared with distances on the earth, yet they are very small when compared with the distances between the earth and the stars.

Motions of the earth. During the yearly journey of the earth around the sun, we are traveling through space at the rate of eighteen miles every second. Every twenty-five minutes we travel a distance equal to the circumference of the earth; every four hours, a distance equal to that to the moon; and every two months, a distance equal to that to the sun.

At the same time we are moving in another direction through the daily rotation of the earth. People at the equator travel at the rate of a thousand miles an hour. We do not realize that we are moving in these two ways, because all the objects on the earth are moving with us and we are all held on the earth by the action of gravity.

The earth is also taking part in still another motion, since the entire solar system — the sun and all its planets — is rushing through space at a speed of twelve miles a second.

THE SUN

The sun is the center of the solar system; around this center the planets revolve. It is by far the largest body in the system. Its diameter is approximately nine hundred thousand miles, or about one hundred times that of the earth. If the size of the earth were represented by a marble a half inch in diameter, it would take a sphere four feet through to represent the sun; or if a baseball were to represent the earth, it would take a sphere about twenty-five feet in diameter to represent the sun. If we could imagine the earth placed at the center of the sun with the moon at its average distance away, the sun would extend out to the moon and almost as far beyond it.

The distance from the earth to the sun varies from month to month. The average distance is ninety-three million miles. Strange as it may seem, we are nearer the sun in winter than in summer.

Sun's heat. The sun is the source of the heat and light that make life possible on the earth. Without the sun's heat every living thing on the earth would perish. We naturally wonder how the sun is able to give out so much heat for such long periods of time. We know that it is not by the ordinary process of burning with which we are familiar; because if it were so, the sun would have burned up before this. Astronomers tell us that a part of the heat is caused by the contraction of the sun, and that the sun is all the time becoming smaller. The change is so slight, however, that even with the most powerful telescope, man cannot notice any difference in the size of the sun.

Composition of the sun. One very remarkable thing that man has been able to do is to learn some of the materials of which the sun is made, although it is at such a great distance. This knowledge has been obtained by means of the spectroscope, which is an instrument for making and viewing a spectrum. When sunlight passes through a glass prism of a certain shape, the ordinary white light is broken up into a number of colored lights, as in the rainbow. When this spectrum is looked at with a telescope, it is found to be crossed by a great many dark lines. From the number and position of these lines, it is possible to tell what substances must be in the sun in order to make them, because the lines are the same as those made by certain substances found on the earth. Such metals as iron and nickel have been found to be present in the sun. By means of the spectroscope, the element helium was discovered on the sun before it was found on the earth. It is to be expected that the same elements would be found in both the earth and the sun, because it has been believed by many that they came originally from the same mass.

The outer surface of the sun is made up of gases heated to an extremely high temperature. Formations called sun spots are frequently seen on the surface of the sun. These are believed to be enormous depressions or craters in the gases. Farther in from the surface, the gases become very dense, and in the center they may become liquid or even solid.

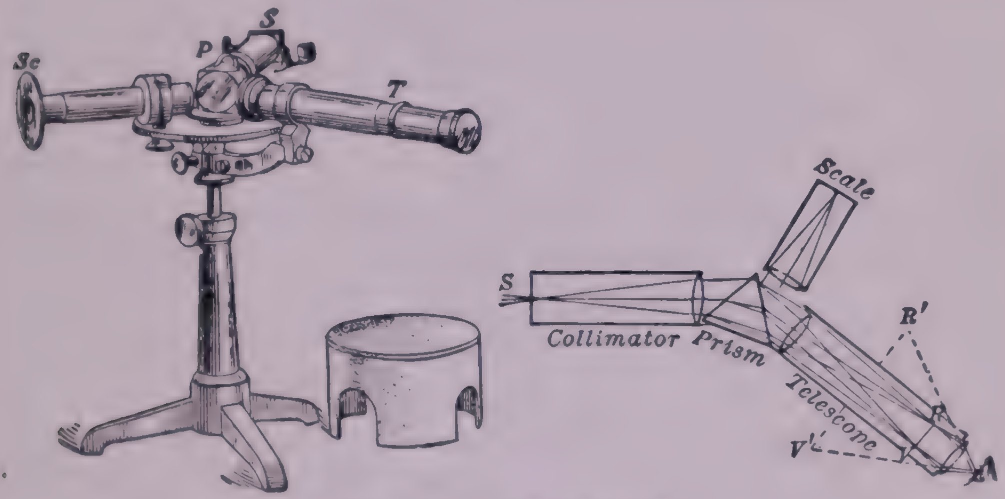

Fig. 209. — Spectroscope

An instrument by means of which many things have been learned about the sun and the stars.

The sun is found to rotate on its axis like the earth, only its period of rotation is longer. Observation of sun spots shows that it takes the sun about twenty-five days to rotate once.

THE MOON

As the earth revolves around the sun, so the moon revolves around the earth. While the earth's motion around the sun takes a year, the moon's motion around the earth takes a month

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(29½ days). It is the nearest of the heavenly bodies, being situated about a quarter of a million miles distant. Its diameter is about two thousand miles, or one quarter that of the earth.

Light of the moon. The moon affects man in two ways — by giving light and by causing tides. The moon gives enough light so that in some towns and cities the electric street lamps are not lighted on clear moonlight nights, thus effecting a saving in expense. The light that we get from the moon is reflected sunlight, as the moon has no light-giving power in itself.

Tides. Another way in which the moon affects life on the earth is by causing the tides. The tides have a beneficial effect, as they help to clear away decaying matter around the shores, which might otherwise collect and become offensive. The tides also have an influence on commerce. They are caused by the attraction of the moon and the sun. The sun is so far away that, in spite of its great size, it has less influence than the moon.

Moon's phases. Each month the moon goes through certain changes or phases, first showing a small crescent, then increasing in size till the full moon is reached, and then decreasing. Only that half of the moon is lighted that is turned toward the sun, and the phase of the moon depends on the part of this lighted portion that we can see. When the moon is between the sun and the earth we see none of the lighted portion; this stage is the new moon; then, as the moon revolves around the earth, a portion shows — the first quarter; and when the moon is on the opposite side of the earth from the sun we see the entire lighted surface — the full moon. Then, as it revolves through the other half of its orbit, the lighted portion gradually grows less.

During this period of revolution the moon rotates once on its axis, so that it always keeps the same surface towards us. No human being has ever seen the other side of the moon.

Superstitions about the moon. *Effect on crops.* From the earliest times we find reference to influences that the moon was supposed to have on weather and the growth of crops. One of these superstitions, connected with the best time for planting seeds, was that seeds would grow better if they were planted at certain phases of the moon.

Effect on weather. Another even more common superstition about the moon, still held even today by some intelligent people, is that the moon affects the weather. These supposed influences may be grouped under two classes.

Ring around moon. In the first class are certain cloud effects produced in connection with the moon, such as a ring around the moon, and the supposed effect of the moon in clearing away the clouds. In both these cases the moon through its light simply discloses a condition that exists in the air, but in neither case did the moon cause the condition. A ring around the moon simply shows the gathering of clouds and the presence of moisture in the air, which may indicate the approach of a storm. When the new moon is supposed to clear away the clouds, it simply means that the light shines through the clouds and thus shows their thinness; this is wrongly interpreted to mean that the moon caused the thinning.

The moon's phases and the weather. In the second class of the supposed influences on weather are those based on the phases of the moon. It is said that as the phases of the moon change, the weather changes, and that the kind of change depends on the hour of the day or night when these changes of the moon occur. In accordance with one prophecy, if the tips of the crescent moon point up, it means a wet season; while in accordance with another prophecy, this means a dry season. This is a very convenient means of prophesying the weather, as one may take his choice as to whether he will have dry or wet weather.

As a matter of fact there are no abrupt changes of the moon, since the phases are gradually changing all the time. The phases of the moon and the position of the crescent points can be foretold thousands of years ahead, while the weather can be foretold only a few days ahead.

Careful records have been kept of weather changes and of the changes of the moon, and none of these records show any definite fixed relation between the two. The relations that exist in one part of the country may be quite different from those in another part of the country.

In conclusion it may be said that there has been no evidence produced to show that the moon does influence weather; while the studies that have been made indicate that there is no constant relation between the moon's phases and the weather. If the moon does have any influence on the weather, it is so slight that it has not yet been detected.

In a bulletin published by the United States Weather Bureau the matter is summarized as follows:

> A review of the foregoing remarks and opinions regarding the application of past and present astronomical and meteorological knowledge to the theory and practice of long-range weather forecasting leads to the following conclusions:
>
> 1. That systems of long-range weather forecasting that depend upon planetary meteorology, moon phases, cycles, positions, or movements, stellar influences, or star divinations, indications afforded by observations of animals, birds, and plants, and estimates based upon days, months, seasons, and years have no legitimate bases.
>
> 2. That meteorologists have made exhaustive examinations and comparisons for the purpose of associating the weather with the various phases and positions of the moon in an earnest endeavor to make advances in the science along the line of practical forecasting, and have found that while the moon and perhaps the planets exert some influence upon atmospheric tides, the influence is too slight and obscure to justify a consideration of lunar and planetary effects in the actual work of forecasting.

Appearance of surface. When looked at with a telescope or even a field glass, the surface of the moon may be seen clearly; and it shows some interesting features. The most conspicuous one is the large number of volcanic craters scattered over its surface, which are much more numerous than on the earth. Thirty thousand craters have been counted on the half of the moon turned towards us. Some of these craters are over fifty miles in diameter, or more than five times the diameter of the largest crater on the earth. Immense mountains are also found on the moon, some ranging from six to seven miles in height,

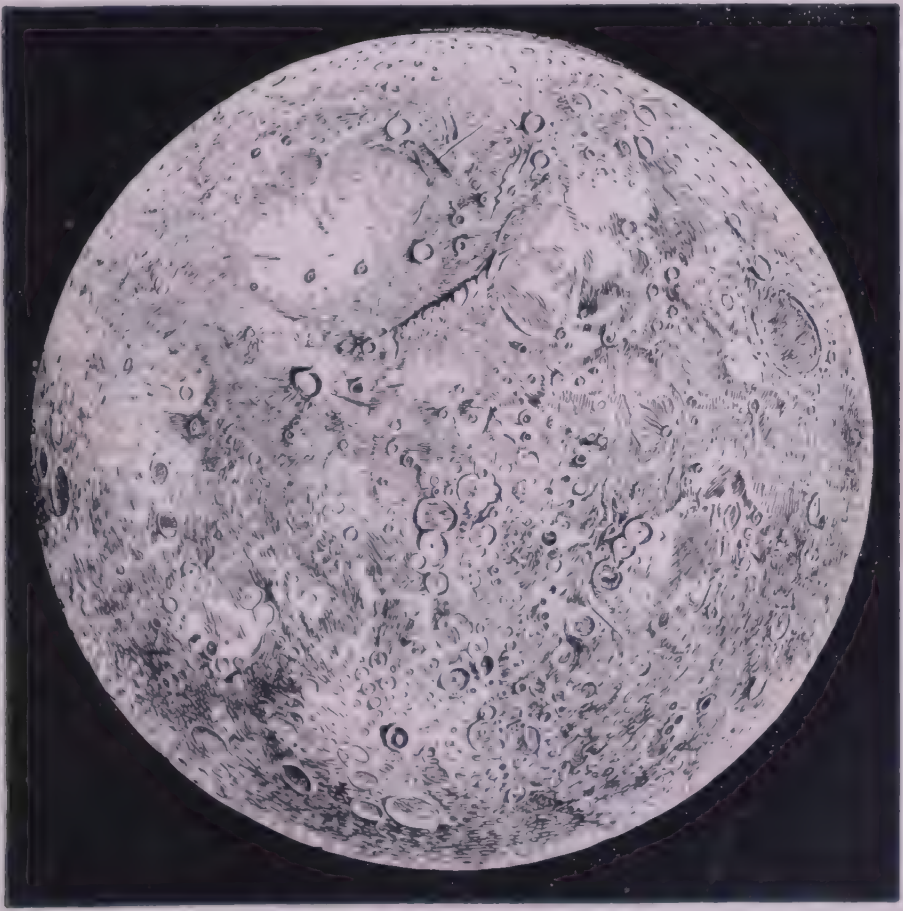

Fig. 210. — **Features of the moon as seen in a telescope, showing the large number of volcanic craters**

exceeding any mountain on the earth. These craters show that formerly there was volcanic activity on the moon; but now the moon has cooled down.

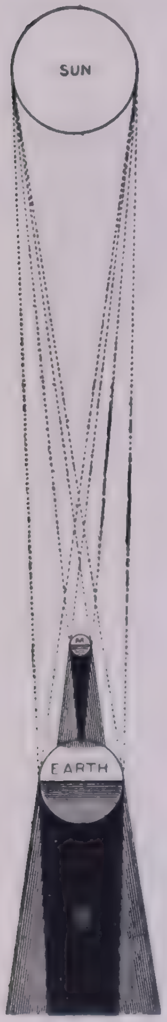

Fig. 211.— How eclipses of the sun and moon take place

There is no air on the moon, and there is no water. Hence there are no clouds and there is no diffused light. Only those objects can be seen that stand in the direct sunlight. As there is no air, no sound could be heard. The force of gravity is so small that a ball player could bat a baseball a half mile.

ECLIPSES

When the sun shines on the earth and the moon, a long shadow extends from the side of these bodies away from the sun. This shadow is in the form of a cone many thousands of miles long — indeed longer than the distance between the earth and the moon. When the earth is between the sun and the moon (figure 211), the moon at certain times may pass into this shadow and so be eclipsed. This shadow is big enough so that the moon may be entirely covered.

When the moon is between the earth and the sun, it sometimes happens that the moon's shadow falls on some part of the earth; this condition causes an eclipse of the sun. This part of the moon's shadow is very small — less than two hundred miles in diameter — so that the sun is eclipsed for only a small part of the earth at any one time. These eclipses can be foretold many years ahead with great exactness. This ability to foretell so exactly the motions of these distant bodies makes us wonder at the skill of the astronomer.

THE PLANETS

The earth is one of a group of eight planets, all of which revolve around the sun in the same direction and in nearly the same plane. The four brightest of these are Jupiter, Venus, Mars, and Saturn. The other three are Mercury, Uranus, and Neptune. At first sight the planets look like stars; yet two differences may be easily noticed. In the first place, the planets do not twinkle; and in the second place, if the planets are watched for several weeks their position in the sky with reference to the stars changes, while the stars always keep the same position with reference to each other.

The planets also show a change in brilliancy and apparent size from month to month, because their distance from the earth changes, according to whether the earth and the planet are on the same side or on opposite sides of the sun. Mars when farthest away from the earth is seven times as far as when nearest the earth. Those planets which are nearer the sun than is the earth — Mercury and Venus — are never seen at any great angular distance away from the sun, and so they are visible only for a few hours before sunrise or a few hours after sunset. Venus is the planet most commonly seen as a "morning" or an "evening star."

The source of the light that comes from the planets is the same as the source of the light from the moon — reflected sunlight. It is thought that perhaps Jupiter may give out a small amount of light of itself.

These planets vary greatly in size. The two smallest — Mercury and Mars — are about one half the diameter of the earth. Venus is about the same size as the earth; while Jupiter, the largest, has a diameter about ten times that of the earth. Mercury is the nearest to the sun of all the planets, less than one half as far as the earth; Neptune is the farthest away, about thirty times the distance of the earth. The time that it takes each planet to make a single revolution around the sun depends on the distance from the sun, the planets farther away taking a longer time. The period for Mercury, the planet nearest the sun, is about three months; while that for Neptune, the one farthest away from the sun, is a hundred and sixty-five years.

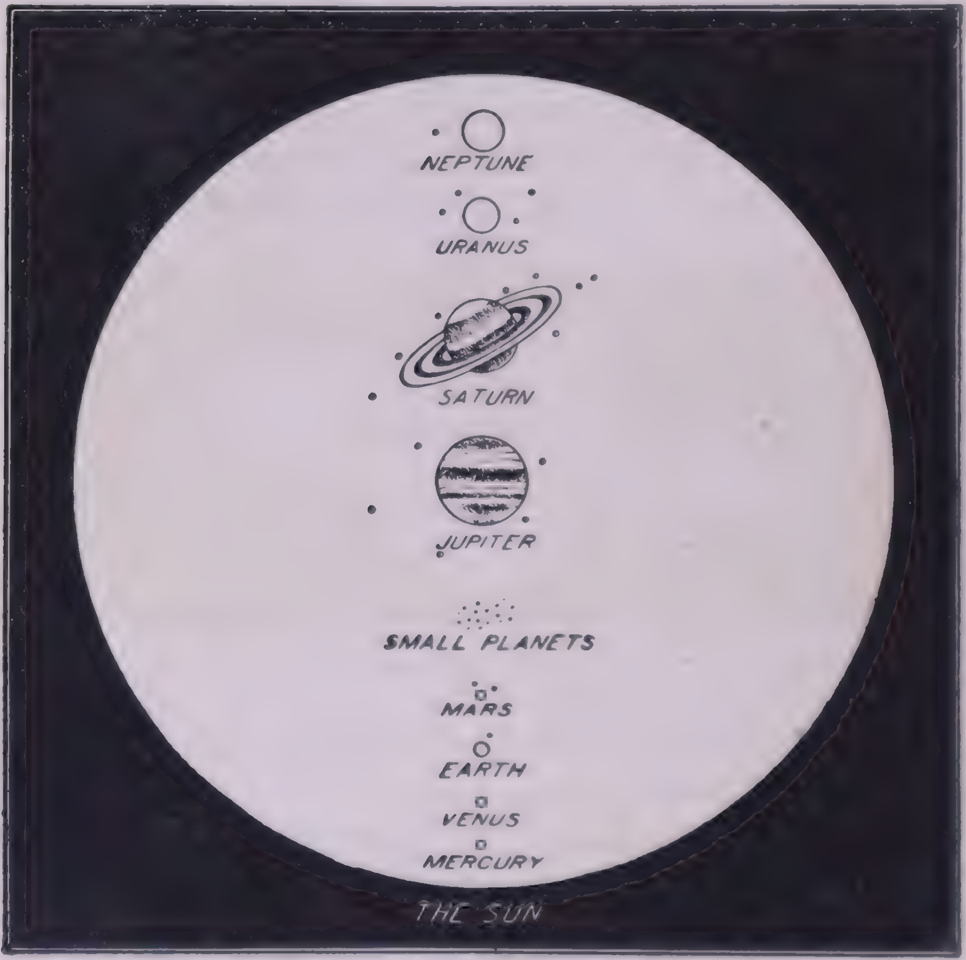

Fig. 212. — Relative sizes of planets

The sun's diameter on the same scale equals the diameter of the large circle.

Most of the planets have moons; Saturn has ten. Another interesting feature about Saturn is its rings, which extend in broad, thin belts around the planet in the plane of its equator. These are very beautiful when seen through a telescope.

Is Mars inhabited? The most interesting of all the planets is Mars. The conditions on Mars are believed to be such that the existence of life similar to that found on the earth is possible. Some astronomers believe that Mars is inhabited. Others think we have not yet secured enough evidence to prove that it is inhabited. The reasons for believing it inhabited are found in the appearance of the surface as seen with the telescope. Some astronomers claim that they have found straight lines, which sometimes appear parallel, as pairs. They argue that this arrangement could not happen by chance, but that there must be intelligent beings there. Their explanation is that these lines, called canals, are belts of vegetation along irrigation canals; that water is scarce, and that as the snow melts from about the poles in the summer the water is carried by those canals to other parts of the planet to be used for irrigation. There are changes in appearance, as though snow accumulated around the poles at one season of the year and then melted during another season.

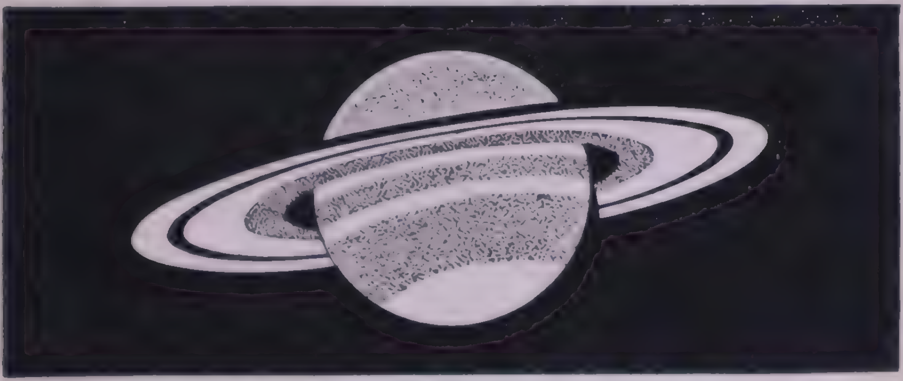

Fig. 213. — The planet Saturn in 1894, as seen with the telescope

Other astronomers dispute the existence of any such straight parallel lines. While it cannot be considered proved that Mars is inhabited, it certainly is a very entertaining theory. Wells, the English novelist, has written a very interesting book called "The War of the Worlds," in which he supposes that the inhabitants of Mars come to the earth and wage warfare against the inhabitants here, but are finally killed by bacteria.

THE STARS

Number. The first thing that impresses one as he looks at the night sky is the number of stars. But while there are a great many, the number seen is not so great as one thinks. Only about two thousand stars can be seen by the unaided eye at any one time. In the course of the year about five thousand stars may be seen. There are many other stars not visible to the eye that can be seen by the telescope; it has been estimated that there are one hundred million stars that may be seen by using this instrument. The camera takes pictures of stars that not even the telescope can detect. How many stars there may be altogether, no one knows Some astronomers have estimated that the stars of the stellar system are numbered by the thousands of millions.

Difference in brightness. Stars differ in their brightness. Some are very bright and can be easily seen, while others can just barely be seen, and most cannot be seen at all without the telescope. This difference may be due to either of two things — to difference in distance or to a difference in the light-giving power of the star.

In accordance with their brightness stars are divided into magnitudes — the brightest being called stars of the first magnitude; the next brightest, stars of the second magnitude; and so on. The stars of the sixth magnitude are the faintest ones that are visible to the naked eye. The following table shows fifteen stars of the first magnitude visible in the United States:

SUMMER STARS		WINTER STARS	
Name of Star	Constellation in Which Located	Name of Star	Constellation in Which Located
Altair	Eagle	Aldebaran	Hyades
Antares	Scorpion	Betelgeuse	Orion
Arcturus	Boötes	Capella	Charioteer
Deneb	Northern Cross	Fomalhaut	Piscis Australis
Regulus	Sickle	Pollux	Twins
Spica	Virgin	Procyon	Little Dog
Vega	Lyre	Rigel	Orion
		Sirius	Great Dog

Size. Stars are self-luminous, like our sun. Indeed, our sun is a small star, but it looks bright because it is so near. Astronomers estimate that the largest stars have diameters several hundred times as great as that of our sun. We may think of stars, then, as large suns scattered through space. The brightest of all the stars is Sirius, the Dog Star, seen during the winter months. It has been estimated that this gives out as much light as thirty of our suns.

Astronomers are able to estimate the size and distance of some stars. The star Mira (meaning "the wonderful") is estimated to have a diameter of 250,000,000 miles — almost three times the distance between the earth and the sun. If the men who flew around the earth could make a similar trip around Mira, keeping the same rate of speed, it would require 15,000 years to fly around this giant star. And the star Antares is believed to be even bigger than Mira.

Distance of stars. The most marvelous and awe-inspiring fact about the stars is the enormous distance at which they are situated. They are so far away that the mile is too small a unit to use in measuring these distances. Therefore astronomers have devised a new unit which is called the light year, which is the distance that light travels in a year. Light travels at the rate of 186,000 miles in a second; that is, it would travel around the earth seven times in a second. It takes light only five hundred seconds to come to us from the sun. In a year, light would travel almost six trillion miles. This distance, called the light year, is taken as the unit in measuring the distances of the stars. The very nearest of all the stars is so far away that it takes light more than four years to reach us. That is, the nearest star is twenty-five trillion miles away. It takes light from the North Star almost fifty years to reach us, so that the light you see from this star started a short time after the close of the Civil War.

The star Mira, mentioned on a previous page, is estimated to be 169 light years distant from the earth. The light that the astronomers observed in the year 1925 while studying this star started from Mira in the year 1756, several years before the Revolutionary War, while America was still a colony of Great Britain. If this star should now cease giving off light, the people on the earth would not know of this happening till the year 2094, three generations hence, when our great-grandchildren would be living. Other stars are even farther away than this. It is believed that from the very farthest stars it takes light thousands of years to reach us. The dimensions of the entire stellar system must probably be measured in hundreds of thousands of light years.

If we imagine that an airplane could fly to the North Star and that it traveled at the rate of two hundred miles an hour constantly day and night, how long would it take to reach the North Star? Let us suppose that two men entered the plane so that they could relieve each other and keep the plane traveling all the time, and let us suppose that at the end of fifty years these two men were replaced by two more, and so on at the end of every fifty years. An army of five million would be needed to run the plane, and it would take 125,000,000 years to reach the North Star.

Constellations. The stars are grouped together into clusters, called constellations, many of which have been named. Usually, however, there is little similarity between the arrangement of the stars and the object from which the constellation is named. These constellations may be grouped according to the seasons when they are visible in the evening.

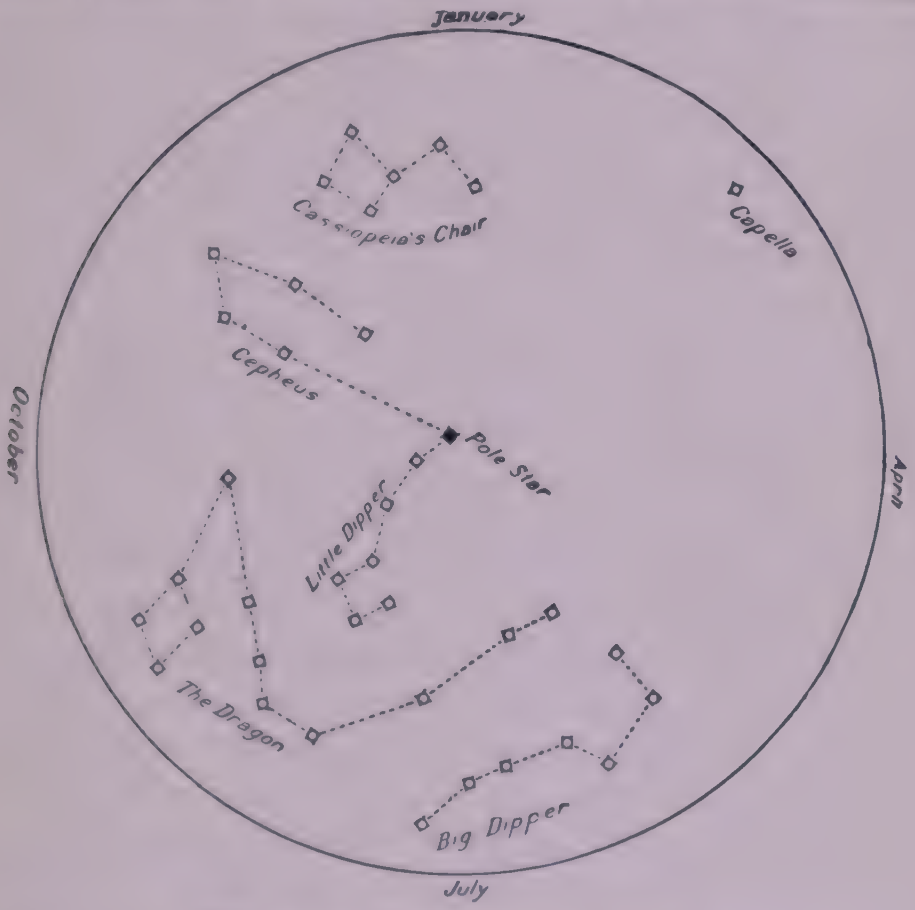

Fig. 214. — The polar constellations

To show their position at nine o'clock for the different months, hold the chart with the name of the month at the top.

All-the-year constellations. All the stars seem to revolve around a point in the heavens near the North Star. Some stars are so near this point that they never set, and hence they can be seen during all parts of the year, although their position varies according to the season. The three most conspicuous of these constellations are the Big Dipper, the Little Dipper, and Cassiopeia's Chair. The Big Dipper can be easily found, as it does look something like a dipper with bowl and handle. The two outer stars in the bowl are called the pointers, because they point towards the North Star. This star lies in the end of the handle of the Little Dipper. The two dippers are so arranged that the open parts of their bowls face each other. In order to find Cassiopeia's Chair, follow the line of the pointers on the other side of the North Star about as far as the distance from the pointers to the North Star. This line stops near a group of stars looking something like a capital *W* pushed out of shape.

Winter constellations. The winter sky exhibits some magnificent constellations, chief among which is Orion. This is so conspicuous that it may be easily found, lying rather low down in the southern sky. Three bright stars near together form the belt; and hanging down from these, three fainter stars form the sword. Two bright stars on one side of these clusters form the shoulders, and two on the other side constitute the heels. If the direction of the stars in the belt be followed eastward, it points to Sirius, the brightest star in the heavens. If the stars in the belt are followed in the opposite direction, they point toward that cluster known as the Pleiades, famed in poetry. Higher up in the sky than Orion and farther toward the west are two bright stars known as the Twins.

Summer constellations. Among the conspicuous summer constellations are Boötes, the Eagle, the Lyre, and the Northern Cross. To find Arcturus, the brightest star in Boötes, follow the curve of the handle of the Big Dipper. The brightest stars in the Eagle, the Lyre, and the Northern Cross form a huge triangle with nearly equal sides, located east of Arcturus. Two of these stars, Vega and Deneb, are high up in the heavens, nearly overhead; while the third, Altair, is lower down toward the south, with a smaller star on each side, Altair and these smaller stars being nearly in a straight line.

It is an interesting study to learn to name some of these constellations, and with the aid of a star map it is not a difficult thing to do.

FIELD EXERCISE 14

Purpose. To learn to name some of the common constellations.

Directions. Secure some star book with star maps, such as Proctor's "Easy Star Lessons" or Comstock's "Handbook of Nature Study." Learn to name first the constellations that can be seen all the year — those near the North Star, such as the Great and Little Dippers and Cassiopeia's Chair. During the winter, study the winter constellations; and during the last of the school year, study the summer constellations. To get the constellations fixed in mind, make in your notebook a diagram of each constellation, showing the position of the stars with reference to each other.

(This may also be given as a home project, in preparation for which the instructor will make on the board a diagram of the constellations, showing the position of the stars, and will explain how to find them.)

What the spectroscope shows about the stars. Since the stars are so far away, it would seem almost impossible to find out anything about them. But the light that comes from the stars tells certain facts about them; and by allowing this light to pass through a spectroscope, astronomers have learned two facts about stars — their composition and their motions. Some of the spectra of stars are so much like the spectra of the sun that they show that some of the elements found in the sun and the stars are the same.

Furthermore, the spectroscope is able to tell us something more than the composition; it tells us whether the star is moving toward us or away from us, and at what speed it is moving. Some stars are moving at the rate of thirty miles a second. It is a mistake to speak of the stars as being fixed, because all heavenly bodies are in motion. Some stars have been traveling at the rate of twenty-five or more miles a second for countless years; and yet within historic times — since man has begun to make any accurate records of the position of stars — they seem to be in the same relative positions as thousands of years ago. They are so far away that the distance they have

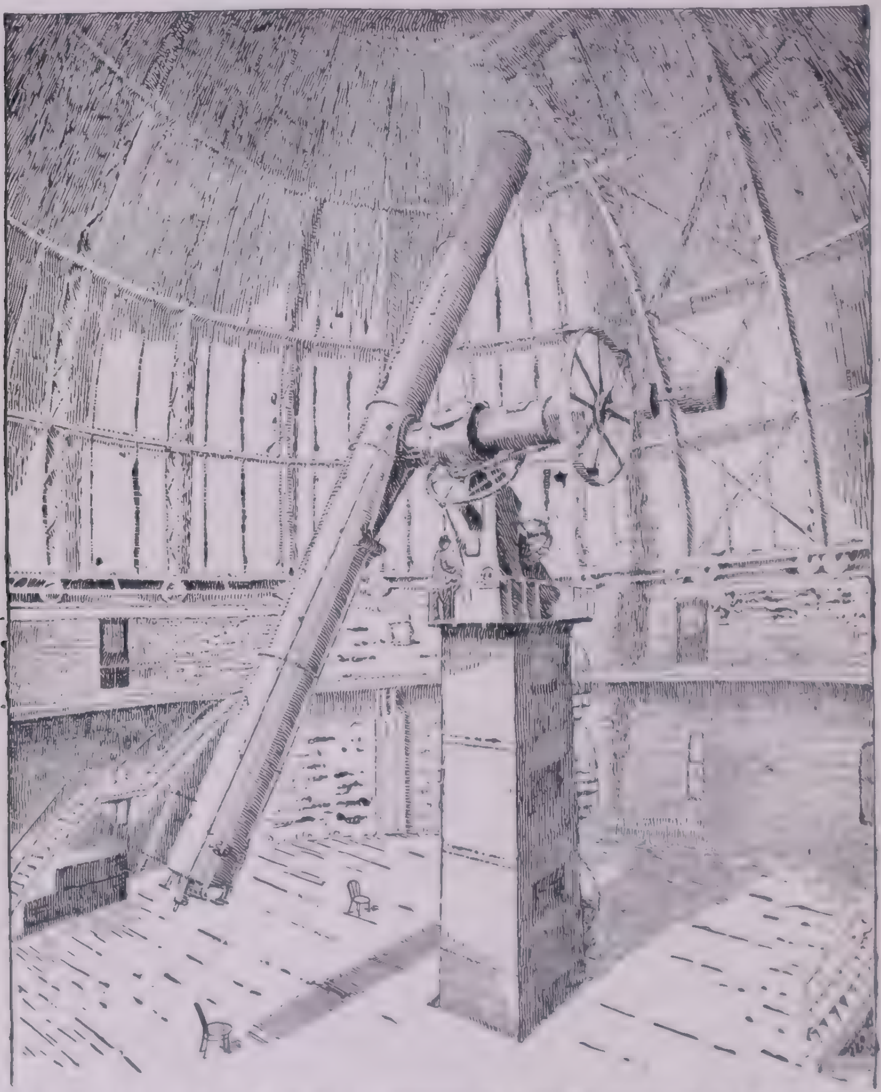

Fig. 215. — The Yerkes telescope of the University of Chicago
Cost, about $125,000. Lenses, forty inches in diameter.

traveled makes no difference in the position of the stars, as far as men can detect with the naked eye. This fact illustrates again the enormous distances that separate us from the stars.

THE TELESCOPE

Many of the facts known about the heavenly bodies have been learned through the use of the telescope. This is an instrument for looking at distant objects and making some of them appear larger than they do to the naked eye. When used for observing stars, telescopes are important because of their light-gathering power, making the stars appear brighter but not magnifying them. There are two types of telescopes: the reflecting, which uses mirrors; and the refracting, which uses lenses. In the refracting telescope are two convex lenses mounted at the two ends of a tube. The lens pointed toward the object is called the objective; the lens at the other end is called the eyepiece. The objective forms an image of a distant object somewhere inside the tube, and the eyepiece is placed in such a position that it is focused on this image and enlarges it.

OUTLINE SUMMARY

THE EARTH'S NEIGHBORS IN SPACE

I. The solar system
    1. Changes in the solar system
    2. Relative distances of heavenly bodies
    3. Motions of the earth

II. The sun
    1. The sun's heat
    2. Composition of the sun

III. The moon
    1. Light
    2. Tides
    3. Phases
    4. Superstitions about the moon

        - *a.* Effect on crops
        - *b.* Effect on weather
            - (1) Ring around moon
            - (2) Moon's phases
    - 5. Appearance of the surface

- IV. Eclipses

- V. The planets
    - 1. Is Mars inhabited?

- VI. The stars
    - 1. Number
    - 2. Difference in brightness
    - 3. Size
    - 4. Distances
    - 5. Constellations
        - *a.* All-the-year constellations
        - *b.* Winter constellations
        - *c.* Summer constellations
    - 6. What the spectroscope shows about the stars

- VII. The telescope

QUESTIONS FOR CLASS DISCUSSION

1. What are the relative positions of the members of the solar system with reference to the sun?

2. What does the spectroscope show about the heavenly bodies?

3. What are some superstitions still held regarding the moon?

4. What is the most important way in which the moon affects man?

5. Why is Mars the most interesting of all the planets?

6. In what ways is the earth like the other planets?

7. What interests you most about the stars?

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APPENDIX

RELATIVE HUMIDITY, PER CENT — FAHRENHEIT TEMPERATURES

Dry-Bulb Temp.	Difference between Dry-Bulb and Wet-Bulb Temperature																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
30	89	78	68	57	47	37	27	17	8											
31	89	79	69	58	49	39	29	20	10	1										
32	90	79	69	60	50	41	31	22	13	4										
33	90	80	71	61	52	42	33	24	16	7										
34	90	81	72	62	53	44	35	27	18	9	1									
35	91	82	73	64	55	46	37	29	20	12	4									
36	91	82	73	65	56	48	39	31	23	14	6									
37	91	83	74	66	58	49	41	33	25	17	9	1								
38	91	83	75	67	59	51	43	35	27	19	12	4								
39	92	84	76	68	60	52	44	37	29	21	14	7								
40	92	84	76	68	61	53	46	38	31	23	16	9	2							
41	92	84	77	69	62	54	47	40	33	26	18	11	5							
42	92	85	77	70	62	55	48	41	34	28	21	14	7	0						
43	92	85	78	70	63	56	49	43	36	29	23	16	9	3						
44	93	85	78	71	64	57	51	44	37	31	24	18	12	5						
45	93	86	79	71	65	58	52	45	39	33	26	20	14	8	2					
46	93	86	79	72	65	59	53	46	40	34	28	22	16	10	4					
47	93	86	79	73	66	60	54	47	41	35	29	23	17	12	6	1				
48	93	87	80	73	67	60	54	48	42	36	31	25	19	14	8	3				
49	93	87	80	74	67	61	55	49	43	37	32	26	21	15	10	5				
50	93	87	81	74	68	62	56	50	44	39	33	28	22	17	12	7	2			
51	94	87	81	75	69	63	57	51	45	40	35	29	24	19	14	9	4			
52	94	88	81	75	69	63	58	52	46	41	36	30	25	20	15	10	6	0		
53	94	88	82	75	70	64	58	53	47	42	37	32	27	22	17	12	7	3		
54	94	88	82	76	70	65	59	54	48	43	38	33	28	23	18	14	9	5	0	
55	94	88	82	76	71	65	60	55	49	44	39	34	29	25	20	15	11	6	2	
56	94	88	82	77	71	66	61	55	50	45	40	35	31	26	21	17	12	8	4	
57	94	88	83	77	72	66	61	56	51	46	41	36	32	27	23	18	14	10	5	1
58	94	89	83	77	72	67	62	57	52	47	42	38	33	28	24	20	15	11	7	3
59	94	89	83	78	73	68	63	58	53	48	43	39	34	30	25	21	17	13	9	5
60	94	89	84	78	73	68	63	58	53	49	44	40	35	31	27	22	18	14	10	6
61	94	89	84	79	74	68	64	59	54	50	45	40	36	32	28	24	20	16	12	8
62	94	89	84	79	74	69	64	60	55	50	46	41	37	33	29	25	21	17	13	9
63	95	90	84	79	74	70	65	60	56	51	47	42	38	34	30	26	22	18	14	11
64	95	90	85	79	75	70	66	61	56	52	48	43	39	35	31	27	23	20	16	12
65	95	90	85	80	75	70	66	62	57	53	48	44	40	36	32	28	25	21	17	13
66	95	90	85	80	76	71	66	62	58	53	49	45	41	37	33	29	26	22	18	15
67	95	90	85	80	76	71	67	63	58	54	50	46	42	38	34	30	27	23	20	16
68	95	90	85	81	76	72	67	63	59	55	51	47	43	39	35	31	28	24	21	17
69	95	90	86	81	77	72	68	64	59	55	51	47	44	40	36	32	29	25	22	19
70	95	90	86	81	77	72	68	64	60	56	52	48	44	40	37	33	30	26	23	20
71	95	90	86	82	77	73	69	64	60	56	53	49	45	41	38	34	31	27	24	21
72	95	91	86	82	78	73	69	65	61	57	53	49	46	42	39	35	32	28	25	22
73	95	91	86	82	78	73	69	65	61	58	54	50	46	43	40	36	33	29	26	23
74	95	91	86	82	78	74	70	66	62	58	54	51	47	44	40	37	34	30	27	24
75	96	91	87	82	78	74	70	66	63	59	55	51	48	44	41	38	34	31	28	25
76	96	91	87	83	78	74	70	67	63	59	55	52	48	45	42	38	35	32	29	26
77	96	91	87	83	79	75	71	67	63	60	56	52	49	46	42	39	36	33	30	27
78	96	91	87	83	79	75	71	67	64	60	57	53	50	46	43	40	37	34	31	28
79	96	91	87	83	79	75	71	68	64	60	57	54	50	47	44	41	37	34	31	29
80	96	91	87	83	79	76	72	68	64	61	57	54	51	47	44	41	38	35	32	29

APPARATUS FOR DEMONSTRATIONS AND LABORATORY EXERCISES

Flasks; rubber stoppers; glass tubing; rubber tubing; alcohol lamp or Bunsen burner; tumblers; beakers; lamp chimney; test tubes; touch paper; candle; ring stand; thermometer; pneumatic trough; wide-mouthed bottles; iron picture-wire; wire gauze; plates; bicycle pump; kerosene lamp; sling psychrometer; plates of glass; air pump; bell jar with open top; rubber membrane; pint milk bottle; glass model of pump; force pump; tin cup; red and blue litmus paper; tuning fork; sonometer; camera; convex and concave lenses; kodak film tank; printing frame; printing papers; flower-pots; window boxes; bulbs; two bar magnets; horseshoe magnet; iron filings; small pieces of various metals; darning and knitting needles; insulated wire; large bolt; dry cells; electric bell; push-button; sal ammoniac cell; strips of sheet zinc and copper; compass; rulers; insect breeding-cage; pair of field glasses for bird study; model of steam engine; galvanometer; primary and secondary coils (the inner one removable); small motor; dynamo; coffee-pot; small gas engine or a model of one; induction coil; small gyroscope; spring balance; overflow can; catch bucket; shot; thistle tube; set of telegraph instruments (sender, sounder, relay); dissectible telephone; pipette; Petri dishes; culture medium; Snellen's vision chart; collections of samples of woods; aneroid barometer; weather maps.

CHEMICALS FOR DEMONSTRATION AND LABORATORY EXERCISES

Nitric acid; hydrochloric acid; sulphuric acid; ammonia; limewater; potassium chlorate; manganese dioxide; sulphur; calcium carbide; distilled water; potassium permanganate; silver nitrate; calcium sulphate; potassium bromide; lead acetate; iron; alum; iodine solution; granulated zinc; hypo; developing powders; formalin; baking powder; baking soda; cream of tartar; vinegar; salt; washing soda; marble; limestone; granite; sandstone; linseed oil; lead nitrate; potassium iodide; mercuric chloride; carbon tetrachloride.

TABLE OF INVENTIONS

NAME	DATE	INVENTOR	NATIONALITY
Steam engine	1774	Watt	English
Steamboat	1807	Fulton	American
Locomotive	1814	Stephenson	English
Telegraph	1844	Morse	American
Telephone	1876	Bell	American
Phonograph	1877	Edison	American
Incandescent lamp	1880	Edison	American
Electric trolley	1880	Siemens	German
Automobile	1883	Daimler	German
Moving pictures	1888	Edison	American
Wireless telegraph	1896	Marconi	Italian
Wireless telephone	1900	Poulsen	Danish
Airplane	1903	Wright brothers	American

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